

Navigation New Method
O R, A
TREATISE
O F

Geometrical
Trigonometrical
Arithmetical
Instrumental
And Practical

} *Navigation.*

Teaching,

How to keep a *Reckoning*, both in *Latitude* and *Longitude*, (without *Tables* or *Instruments*) by a *New Method*, never yet published: Illustrated with *Practical Examples* of keeping a *Journal*, and correcting it by an *Observation*; with a *New Way* of Finding the *Variation*, and *Time of High-Water*, at any known *Port*.

Together with

All Necessary *Tables*, and the *Projection* of the *Sphere Orbographick* and *Stereographick*, and the *Solution* of all necessary *Questions* in *Astronomy* relating thereto.

With an *APPENDIX*,

Touching *Currents*, and other useful *Questions*, and how to correct the *Longitude* by a *Solar Observation*.

To which is added,

A *Correct Table* of *Logarithms*, *Sines*, *Tangents* and *Secants*, for the *Benefit* of those that have only learned to work by a *Canon*, or others that may have *Occasion* for them in other *Trigonometrical Calculations*.

By *HENRY WILSON*, *Philomath.*

LONDON: Printed for *Eben. Tracey*, at the *Three Bibles* on *London-bridge*; *Ben. Pickard*, at the *Three Bibles* in the *Minories*; and *W. Meadows*, at the *Angel*, near the *Fleece Tavern* in *Cornhill*. 1715.



Hugh Stewart



To the Honourable,

Horatio Walpole, Esq;

Secretary to the Right Honourable, the
Lord Viscount TOWNSEND, one of
His Majesty's Principal Secretaries of
State, &c.

SIR,

IF I could plead either Acquaintance with
You, or Merit from You, it might in
some Measure have attoned for this my Pre-
sumption; but (although destitute of any such
Plea to introduce my self or my Work into
your Favour and Acceptance) yet the Consi-
deration of your Generous Disposition, and
publick Spirit, attested by your Prudence and
Celerity, in acting for the Common Benefit

A 2

both

both at home and abroad, under so happy a Government. And supposing that the publick Advantage of this Nation consists partly, if not chiefly, in the Encouragement and Improvement of Navigation; these Considerations have animated me to surmount all other Discouragements, and humbly to offer this my Treatise of Navigation New Modell'd, to your Acceptance and Protection; not as Deserving but as Needing so great a Favour; nor daring to plead any thing of Worth, whereby to recommend my self, or my Work, to your Approbation; but humbly craving and hoping, that your Generosity in Acceptance may supply the Weakness of my Performance; with this Hope I am encouraged to subscribe my self,

Honoured Sir,

Your Humbly Devoted

Servant,

HENRY WILSON.



THE
EPISTLE
TO THE
READER.

Courteous Reader,



T may reasonably be expected, that when a Book of this Nature comes to be offer'd to the Press, or expos'd to publick View, it will readily be answer'd, that there are a great many very good Books of Navigation now in Print; and these, many of them, with such useful Improvements, that nothing can be added to render it more compleat: But indeed we must never deny, but that our present Attainments will admit of further Improvements, so long as the Longitude remains to be such a puzzling Subject to our

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best Mathematicians, especially now, in a Day when the Parliament has been pleas'd to offer such a liberal and plentiful Gratiuity to him that shall first discover it : For the supplying of which Want of an exact Method to find the Longitude, I have, towards the latter End of this Treatise, inserted a very useful Method for finding the Longitude by the Sun, any Day at Noon, when the Sun can be seen : But to wave this Subject, we find that Mathematical Studies did hitherto, and do yet admit of Improvement : For in former Times, when Mathematical Sciences were in their Non-Age, and *Minerva's* Fruit did not grow in so many *English* Gardens as it doth now, it was thought (and indeed was) an extraordinary Attainment in Trigonometrical Operations, when the Antients found out the Way of applying Right Lines to Arches of Circles, which we call Sines, Tangents, and Secants, and could thereby perform their Trigonometrical Calculations, altho' with the vast Trouble of multiplying by 5, 6, 7, or 8 Figures, which took up a large Quantity both of Time and Room ; but this Manner of Operation was much facilitated by my Lord *Napier's* admirable Invention of Logarithms, with the Improvement of Mr. *Henry Briggs*, the Use of which is now so common, that he would be thought but a slender Mathematician, that knows no other Way of Operation than by Multiplication and Division, the Trouble whereof is now thought intolerable : To this we may add the Invention of *Gunter's* Scale, both long and sliding, upon which,

which, with a Turn of a Pair of Compasses on the one, or only removing the other, are performed those Propositions in *Trigonometry* which formerly required Abundance of Figures in the Operation; but all this not being thought sufficiently expeditious at Sea, there have been also invented Tables ready calculated, called *Traverse Tables*, or *Tables of Difference of Latitude and Departure*, wherein, by Inspection only, you may answer any Question in any of the six Cases of *Plain Sailing*, and also find the Difference of Longitude, as is taught at large in this Treatise: But of all the Improvements that have been made, I never heard of any that ever attained to a Method for solving all the Cases in *Trigonometry*, and *Practical Navigation*, viz. the Keeping of a Reckoning both in Latitude and Longitude, with sufficient Exactness, without any Tables, Books or Instruments, or any other Help, but only Pen and Ink, or a Piece of Chalk; and this is what I have presented to the World in this Treatise, and which I take for granted was never Taught nor Printed before, excepting that Proportion by which I have wrought the sixth Case of *Plain Sailing* by the *New Method*, which we find hinted at by *Snellius*, in his *Cyclometria* quoted by Mr. *Collins*, in his Book entitul'd, *The Plain Scale new Plain'd*, &c. in the Title-Page of which Book he enumerates amongst the rest of the Contents, [*Arithmetical Navigation, or Navigation perform'd by the Pen, if Tables were wanting, &c.*] at the first Sight of which I thought my Design had

A 4 been

been anticipated, till looking further into the Book where he is upon that Subject, (*viz.* in Page 118 of the first Book) I find he touches upon no more but only that Case, where three Sides of a right-angled Triangle is given (or found) to find an Angle; but (in Page 120) speaking of that Case of one Side, and two Angles given, to find the other Sides, he ingenuously owns that it cannot be done without a Table of Sines, and this is what I have laid down in this Treatise, *viz.* The Solution of all the other five Cases of *Plain Sailing*, or any other Operation that depends upon a right angled plain Triangle, with as much (if not more) Ease and Exactness as that is perform'd there, which encouraged me to proceed to the compleating of that new Method, which I thought should only have been the Subject of this Treatise, when I first thought of appearing in publick. But supposing that those who had learn'd the whole Art of Navigation, both *Geometrical*, *Trigonometrical*, and *Instrumental*, as it is commonly taught in Schools, and practis'd at Sea, would be discourag'd from buying the Book, when they found nothing in it that they had formerly learnt. Therefore, for the sake of such, and to make the Book universally useful, I resolved to make it a compleat Treatise of Navigation, as perform'd;

First, Geometrically, by Projection, with Chords and equal Parts.

Secondly, By Trigonometrical Calculation by Logarithms, Sines and Tangents.

Thirdly,

The Epistle to the **READER**

Thirdly, By Inspection in the Traverse-Table.

Fourthly, Arithmetically, by Given Numbers.

Fifthly, Instrumentally, by Scale and Compasses.

Sixthly, By the New Method, with only Pen and Ink.

Lastly, Practical Navigation in several Parts ;

First, How to find the Variation of the Compass by an easy Method, without Trigonometrical Calculation, Azimuth, or Amplitude; whereby they that can neither write nor read may do it as well as the best Mathematician.

Secondly, How to divide the Log line, and Reasons given for the Length assign'd for one Knot thereof.

Thirdly, The best Method for Taking and Working an Observation, contracted into four Cases or Varieties, which answers all Places in the World, and all Times of the Year.

Fourthly, How to reckon the Tides, by a Method so easy, that you may thereby find the Time of High-Water at any known Port, only by a Sight of the Moon, at any Time of the Day or Night, illustrated by a Diagram, or Figure, in which, indeed, to have been exact, the light Part of the Moon's Body should have been determined by Ellipsis's, and not by Arches of Circles, as is evident from the Analemma, if we compare the Position of the Eye, with respect to the Moon, with the Position of the Eye with Respect to the Orthographick Projection ;

x *The Epistle to the READER.*

jection; but I have contented my self with those circular Divisions, because they are easier perform'd, and serve as well to illustrate the Matter for which they are projected.

And here by the Way, we may take Notice of one Observation with Respect to the Tides, though for some Reasons omitted in its proper Place, *viz.* Whether the Moon in Perigeon, by Reason of her Nearness to the Earth, may not have a greater attractive Influence upon the Water; as also whether a greater Congress of Planets about the Sun or Moon, at the New or Full Moon, may not conduce something to the Augmenting of the Tides, by contributing their (tho' but small) Attraction, when other more substantial Reasons there mentioned do concur; and this I am rather induced to believe, because the Truth hereof has been confirm'd to us by an Instance within the Reach of our own Experience; for at the New Moon in *September 1709.* there was such a Confluence of Natural Causes of the Tide: For first, the Moon was then with the Sun. Secondly, it was the Luration next after the Autumnal Equinox. Thirdly, The Moon was at or near her Perigeon. Fourthly, The three Planets *Mars, Venus* and *Mercury*, were all within less than 30 Degrees of the Sun and Moon; yea some within 15 Degrees, and *Jupiter* was within 35 Degrees of the Sun and Moon, and this Luration was attended with such exuberant Tides, that in the low Ground in *Yorkshire*, over-against *Stockton*, where the Tide never comes but in very high Spring Tides,
it

The Epistle to the **READER.** **xi**

flowed 2 or 3 Foot Water, and doubtless at
other Places it was proportionable, which seems
to confirm the Truth of this more than proba-
ble Conjecture, and render it worthy the Ob-
servation of the Ingenious.

Fifthly, How to make your own Charts for
any Voyage several Ways.

Lastly, The Application of the whole to the ac-
tual Keeping of a Reckoning both in Latitude
and Longitude, sailing large, or upon a Wind;
and how to make all proper Allowances for Lee-
Way, Variation, &c. and how to correct your
Reckoning by an Observation, with Reasons
and Demonstrations of the different Ways of do-
ing it. One and the same Day's Work in the
Journal, as well as one and the same Question
elsewhere in the Book, being perform'd both by
the common Method, and also by the New
Method, that the Reader may see the Truth
and Certainty thereof.

With an Appendix, shewing how to project
and answer the various Cases and Questions re-
lating to Currents, with other useful Questions,
concluding with an useful Method for finding or
correcting the Longitude, without Help of the
dead Reckoning.

And although here are Ways proposed for
Answering all necessary Cases without Loga-
rithms, &c. yet to make the Book universally
useful, and as much as can be to answer the
End of all Buyers, as well the Learner at School,
as the accomplish'd Mathematician in his Tri-
gonometrical Operations, we have added a cor-
rect

xli *The Epistle to the* **READER.**

rect Table of Logarithms, Sines and Tangents,
which concludes the whole. Thus desiring a fa-
vourable Construction to be put upon what
Faults may escape either the Pen or the Press;
I question not, the noble hearted Sailors Ac-
ceptance; which that it may be a Benefit to
the Buyer, a Help to the Learner, a fit Com-
panion for the Mariner, and a Credit to the
Author, is the Desire of,

Yours to Serve you,

London, Sept. 29.

Henry Wilson.

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NAVIGATION

New Modell'd.

CHAP. I.

NAVIGATION Geometrical.

SECT. I.

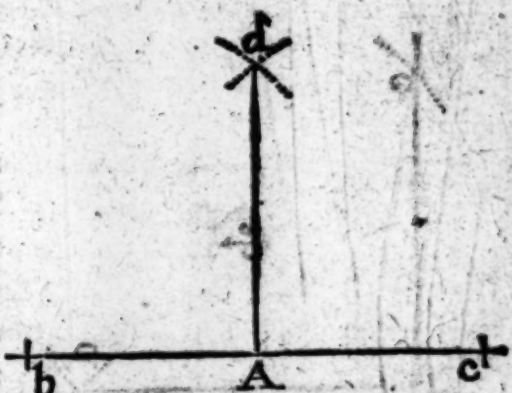
Geometrical Problems.

PROB. I. *From a Point given in the Middle of a Line, to erect a Perpendicular.*

WITH your Compasses open'd at any Extent, and one Foot in the given Point *A*, make the

Marks *b* and *c*; then with any greater Extent, and one Foot in *b*, make an Arch, as at *d*, and with the same Extent, and one Foot in *c*, cross the said Arch at *d*; then from the crossing of the said Arches to

the Point *A*, draw a Line, it is the Perpendicular required.

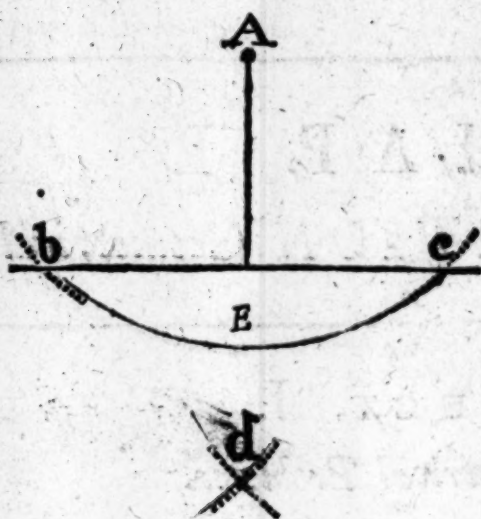


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PROB.

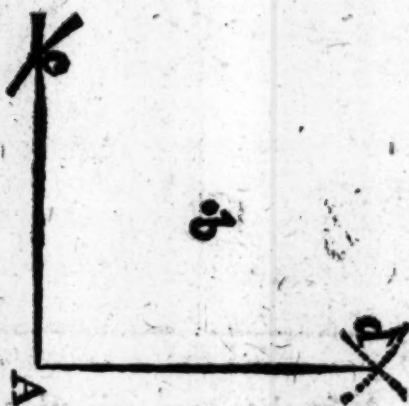
PROB. II. *From a Point given above a Line, to let fall a Perpendicular.*

With your Compasses open'd to any Extent (more than the nearest Distance from the given Point to the given Line) and one Foot in the given Point *A*, cross the given Line in *b* and *c*; then with any Distance more than half the Distance between *b* and *c*, and



one Foot in *b*, draw the Arch *d*, and with the same Extent, and one Foot in *c*, cross the said Arch at *d*; then lay a Scale from the Point *A* to the crossing of the Arches at *d*, so draw the Line *A E*, which is the Perpendicular required.

PROB. III. *How to raise a Perpendicular upon the End of a given Line.*



With your Compasses at any Extent, and one Foot in the given Point *A*, make a Mark at any convenient Distance above the Line, as at *b*; then keeping one Foot in the Mark *b*, with the same Extent cross the given Line at *c*, and turning your Compasses about, make

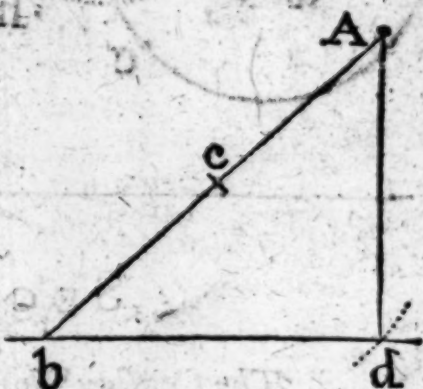
Sect. I. *Geometrical Problems.*

3

make the Arch d ; then lay a Scale from the crossing at c to the Mark at b , and make a Mark where it crosses the Arch d ; so a Line drawn from that Intersection to the Point A is the Perpendicular required.

PROB. IV. *How to let fall a Perpendicular upon the End of a given Line, from any given Point over the End of the said Line.*

Draw a Line from the given Point A to intersect the given Line at any convenient Distance, as at b ; then divide the Line Ab into two equal Parts at c ; and upon c , with the Extent cA , or cb , cross the given Line in d ; then a Line drawn from the given Point A to the Intersection at d , is the Perpendicular required.



PROB. V. *To draw a Line parallel to another Line at any given Distance.*

Take in your Compasses the given Distance, and with one Foot in the given Line, towards each End of it, draw the two little Arches a and b ; a Line drawn from the Extremity of these Arches is the Parallel required.

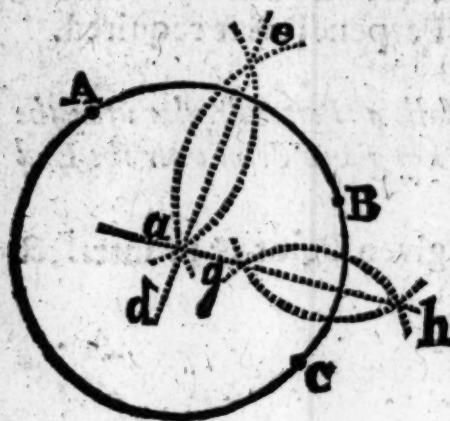


PROB. VI. *To bring any three Points (not situate in a right Line) into the Circumference of a Circle.*

Suppose the three Points be ABC ; first take more than half the Distance AB , and with one Foot in A sweep an Arch; then with the same Distance, and

4 *The Construction of the Sines, &c. Chap. 1.*

one Foot in *B*, draw another Arch to cross the aforesaid Arch in the Points *d* and *e*; then with more than



half the Distance *BC*, and one Foot in *B*, draw the Arch *g b*, and with the same Distance, and one Foot in *C*, draw an Arch to cross the aforesaid Arch in the Points *g* and *b*; then draw the Lines *e a d*, and *a g b*, and where these Lines cross, as at *a*, is the Center of the Circle required.

SECT. II.

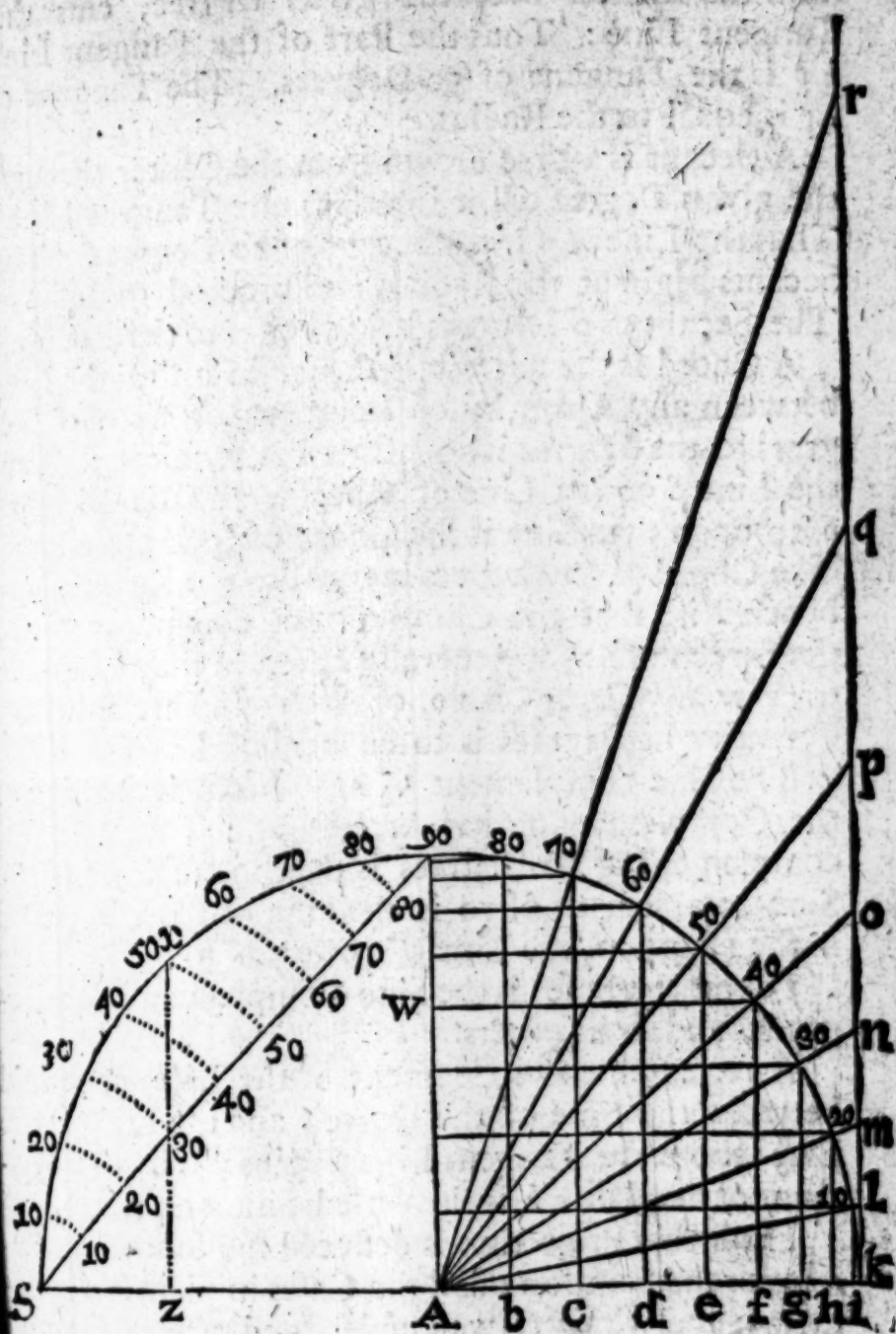
The Construction of the Sines, &c.

EVery great Circle is (suppos'd to be) divided into 360 equal Parts called Degrees, whereof the half, or Semicircle contains 180 Degrees, and the Quarter or Quadrant is 90 Degrees, and upon one Quadrant is projected the Sines, Tangents, &c.

The Radius is the Semidiameter of a Circle, upon which the Projection is made; as *A k*, or *A 90*, or *AS*, is the Radius of the projected Diagram, and is commonly suppos'd to contain 10000 equal Parts.

A Sine is a Perpendicular let fall from the given Degree to the Base or Semidiameter of the Circle; as the Line *g 30*, is the Sine of 30 Degrees, and the Line *b 80*, is the Sine of 80 Degrees, &c. the Sine of 90 Degrees is equal to the Radius.

A Tangent, or Touch-line, is a Perpendicular erected upon the End of the Semidiameter, just so



to touch the Periphery of the Circle : Thus the Line
kr is a Tangent Line. The Tangent of any Degree
 is the Distance from the Beginning or Foot of the
 Tangent Line to that Part of it where a Line, drawn
 from
 B 3

6 *The Construction of the Sines, &c.* Chap. 1.

from the Center over the given Degree, cuts the Tangent Line: Thus the Part of the Tangent Line $k p$ is the Tangent of 50 Degrees. The Tangent of 45 is equal to the Radius.

A Secant is a Line drawn from the Center through the given Degree till it intersect the Tangent Line: Thus the Line $A p$ is the Secant of 50 Degrees. The Secants begin at the Radius, and proceed to Infinite. The Secant of 0 Degrees being equal to the Radius.

A Chord is the nearest Distance in a straight Line between any Quantity of Degrees; or from 0 Degrees to the Degree whose Chord is required: Thus the Line $S 90$ is a Line of Chords, and the Distance $S 30$ upon that Line is the Chord of 30 Degrees, &c. The Chord of 60 Degrees is equal to the Radius, and hence it is, that the Chord of 60, commonly called the Sweep of 60, is generally taken in the Compasses to draw any Great Circle, or Arch of a Circle, whose Quantity in Degrees is to be measured.

The Sine-complement of any Arch, is the Sine of the Complement of that Arch to 90: Thus the Sine-complement of 30 Degrees is the Sine of 60, and the Sine-complement of 70 is the Sine of 20, &c. And in the Diagram, the Line $W 40$ (equal to the Distance $A f$ upon the Base) is the Sine Complement of 40 Degrees, and so in others.

A versed Sine is a Segment of the Base, contain'd between the Sine of the Degree and the End of the Base where the Tangent Line begins; thus the Segment of the Base $e k$ is the versed Sine of 50, &c.

From this Projection is deduced the following *Axioms* for the Solution of all the Cases in plain Trigonometry; and which (if well understood) are the Ground of the whole Art of Navigation, so far as it depends upon plain Triangles, and is solv'd by a Canon; which I shall first shew in the following Cases, and then proceed to shew how it may be done without.

AXIOM

AXIOM I.

In all right-angled plain Triangles, if one Side be made the Radius, the other Sides will be Sines, Sine-complements, Tangents, or Secants, as is evident from the Diagram; for,

Suppose in the Diagram the Triangle Apk , here the Side Ak is the Radius, and the Angle at A being 50 Degrees, the Side pk is the Tangent of 50, and the Hypotenuse Ap is the Secant of 50; and what Proportion the Radius hath to the Side Ak , the same Proportion hath the Tangent of 50 to the Side $k p$, and the same Proportion hath the Secant of 50 to the Hypotenuse Ap .

Again, if you will make the Hypotenuse a Radius, and suppose the Angle at A be 40 Degrees; then in the Diagram it is represented by the Triangle $Af40$, and then the Side $f40$ is the Sine of the Angle at A , and the Side Af equal to $W40$ is the Sine-complement of the Angle at A ; and then what Proportion the Hypotenuse hath to the Radius, the same Proportion will the Side $40f$ have to the Sine of 40, and the same Proportion will the Side Af have to the Sine-complement of 40, &c. and from this Proportion proceeds the second Axiom.

AXIOM II.

In all plain Triangles the Sides are proportionable to the Sines of their opposite Angles, and the contrary; as in the Diagram in the Triangle above-mention'd, $Af40$, it is demonstrated, As the Radius or Sine of 90 to the Hypotenuse, or Side opposite; so is the Sine of 40 to the Side opposite to the Angle at A , &c.

This Proportion commonly call'd, Opposite Sides, Opposite Angles, holds true also in oblique plain Triangles; only observe, That where you have an obtuse

Angle, *viz.* more than 90 Degrees, the Sine of it is found by subtracting the obtuse Angle from 180 Degrees, the Sine of the Remainder is the Sine of the obtuse Angle requir'd.

A X I O M III.

In all Triangles, as the Sum of the Legs of any Angle is to their Difference, so is the Tangent of half the Sum of the other two Angles to the Tangent of half their Difference ; and therefore,

When there are given two Sides, and an Angle included, to find the other Angles, the Proportion is,

As the Sum of the Sides to the Difference of the Sides, so the Tangent of half the Sum of the unknown Angles to the Tangent of half their Difference, which half Difference added to the half Sum, is the greater Angle, and subtracted leaves the lesser.

A X I O M IV.

In all Triangles, as the Base or greatest Side, to the Sum of the other two Sides, so the Difference of the Sides to the Difference of the Segments of the Base, which Difference subtracted from the whole Base, the Perpendicular falls in the Middle of the Remainder ; and so the oblique Triangle is reduc'd to two right angled ones, and may be wrought after the same Manner.

By these Axioms are all the following Cases of plain Triangles solved ; in which observe, In right-angled Triangles, the two Sides including the right Angle are called Legs or Sides, or sometimes Base and Perpendicular ; and the slope Line is called the Hypotenuse, &c.

SECT. III.

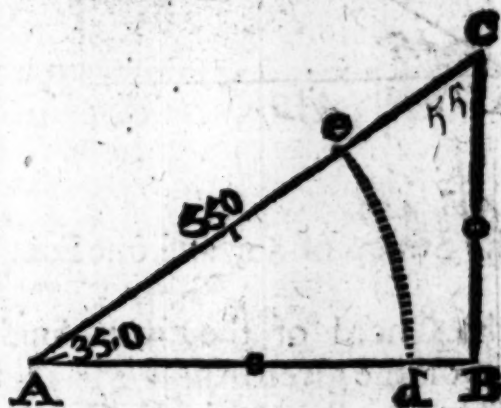
Plain Trigonometry Geometrical.

Plain Trigonometry right-angled.

CASE I. *The Hypotenuse and one acute Angle being given (consequently both) to find either Leg.*

Note, **I**N all plain Triangles the 3 Angles make up 180 Degrees, therefore in all right-angled Triangles, because the right-angle is always 90, the Sum of the other two Angles is also 90; and therefore subtract the acute Angle given from 90, the Remainder is the other acute Angle.

Given Hypotenuse AC 550
 The Angle at A ——— $35^{\circ} 0'$
 Required the Leg AB
 And the Leg BC .



1. In this, and all other Cases, draw the Base AB at Pleasure.

2. With the Chord of 60, and one Foot in A , sweep the Arch de .

3. With

10 *Plain Trigonometry Geometrical.* Chap. 1

3. With the Chord of the given Angle 35° , and one Foot in d , with the other Foot cross the Arch at

4. From A through e draw the Line AC , upon which set off the Hypotenuse 550 from A to C .

5. From C let fall a Perpendicular upon the Line AB , to cut it in B , and 'tis done.

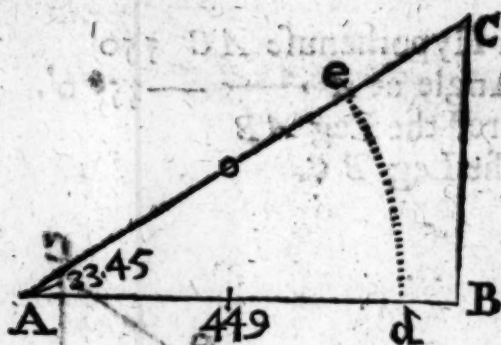
The Leg AB measured on the same equal Parts from which the Hypotenuse was taken, will be found to be $450:5$, viz. 450 and an half, and the Leg BC is $315:5$.

CASE II. *Given the Angles and a Leg, to find the Hypotenuse.*

Given the Angle A ——— $33^\circ 45'$

the Leg AB ——— 449

Requir'd the Hypothenuse AC .



1. Draw AB 449 .

2. With the Sweep of 60 , and one Foot in A , draw the Arch de .

3. With the Chord of the given Angle, and one Foot in d , set off the given Angle $33^\circ 45'$ from d to e .

4. From B erect a Perpendicular BC .

5. Through A and e draw the Hypothenuse AC , till it cross BC in C , and 'tis done.

The Hypothenuse AC measur'd on the Scale of equal Parts will be found to be 540 .

CASE

Sec. 3. *Plain Trigonometry Geometrical.* 31

CASE III. *Given the Angles and a Leg, to find the other Leg.*

Given the Angle A ——— $33^{\circ} 45'$
 the Leg AB ——— 449
 Required the Leg BC .

This is laid down as Case IV, the same Things being given; and the requir'd Leg BC being measured, will be found to be 300.

CASE IV. *Given the Hypotenuse and a Leg, to find an Angle.*

Given, the Hypotenuse AC 540.
 the Leg AB ——— 449.
 Requir'd the Angle at A .



1. Draw AB at Pleasure.
 2. Upon AB set off the given Leg 449, from A to B .
 3. From B erect a Perpendicular.
 4. With the Hypotenuse 540, and one Foot in A , cross the Perpendicular BC in C .
 5. From the said crossing to A draw the Line CA .
 6. With the Sweep of 60, and one Foot in A , draw the Arch de , and 'tis done.
- The Arch de measured on the Chords gives $33^{\circ} 45'$. the Angle requir'd.

CASE

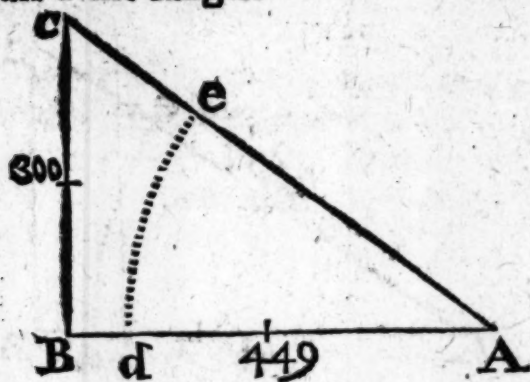
CASE V. *Given the Hypotenuse and a Leg to find the other Leg.*

Given, the Hypotenuse AC 540
 the Leg AB ——— 449
 Requir'd the Leg BC .

The laying down of this is the same as the former because the same Things are given; and the Leg BC measur'd on the same equal Parts from whence the given Parts were laid down, will be found to be 300.

CASE VI. *The Legs given, to find the Angles.*

Given, the Leg AB ——— 449
 the Leg BC ——— 300
 Requir'd the Angles.



1. Draw AB 449.
2. Upon B erect the Perpendicular BC , and thereupon set off 300 from B to C .
3. Draw the Hypotenuse AC .
4. With the Sweep of 60, and one Foot in A , draw the Arch de , and 'tis done.

The Arch de measur'd on the Chords gives 45' the Angle requir'd;

CASE

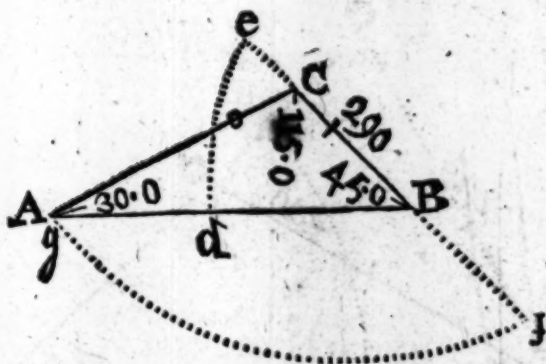
Required the Hypotenuse AC .

This is laid down as Case VI, and the Hypotenuse AC measur'd on the Scale of equal Parts is 540.

SECT. IV.

Of Oblique Plain Triangles.

Required the Side $A C$.



- #### 4. From

14 *Oblique Trigonometry Geometrical. Chap. 1.*

4. From *B* through *e* draw the Line *BC*, and upon it set off the given Side 290, from *B* to *C*.

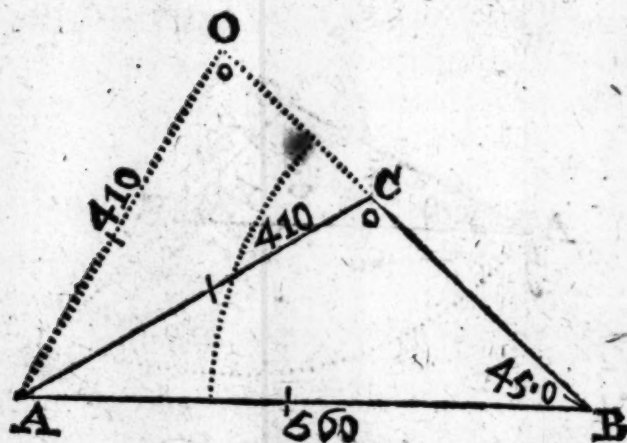
5. The Angles *A* and *B* being given, the Angle *C* is also known, being the Complement of the other two Angles to 180, and will be found to be 115° , and therefore with 60 of the Chords, and one Foot in *C*, sweep the Arch *fg*, upon which set off 115° from *f* to *g*, and through *g* draw the Line *CA* to cut *AB* in *A*, and 'tis done.

The Side *AC* measured on the same equal Parts is 410, the Side requir'd.

Note, When you have any Chord above 90 to set off, you must do it at twice, because the Chords go but to 90, &c.

CASE II. *Two Sides and an Angle opposite to one of them given, to find the Side opposite to the other.*

Given, the Side *AB* ——— 560
 the Side *AC* ——— 410
 the Angle at *B* ——— $45^\circ 0'$
 Requir'd the Angle at *C*.



1. Draw *AB* 560.
 2. Make the Angle *B* 45° , and draw the Line *BC*.
 3. With the Side *AC* 410, and one Foot in *A*, cross the Line *BC* in *C*, and draw the Line *AC*, and 'tis done.
- The

Case 4. Oblique Trigonometry Geometrical

The Angle at C measur'd on the Sweep *de*, gives the Angle at C required.

Note, This Case is ambiguous, and will admit of two Answers; so that it is necessary that it be known whether the Angle at C be acute (that is, less than 90) or obtuse (that is more than 90) for if it be obtuse, the Angle mark'd C is the Angle requir'd; but if acute, the Angle at O is it; for the Side AC 410 taken in the Compasses, and one Foot in A, it will cross the Line BC (continued) both in C and O, &c.

CASE III. Given as in Case II, to find the third Side.

The laying down is the same as in Case II, because the same Things are given; and the Side BC measur'd on the equal Parts is 290, if the Angle be obtuse, or 103 if it be acute.

CASE IV. Two Sides and an Angle between them given, to find either of the other Angles.

Given, the Side AC ————— 410
 the Side AB ————— 560
 the Angle A ————— $30^{\circ} 0'$
 Requir'd the Angle B



1. Draw AB 560 from A to B.
 2. Make the Angle A $30^{\circ} 0'$.
 3. Draw AC 410 from A to C.
 4. From C to B draw the Side CB, and 'tis done.
- The Angle B measur'd on the Chords is $45^{\circ} 0'$.

CASE

CASE V. *Given two Sides, and the Angle between them, to find the third Side.*

Given, the Side AC ——— 410

the Side AB ——— 560

the Angle A — 30°

Requir'd the side BC .

Laid down as Case IV, and the Side BC measure is 290.

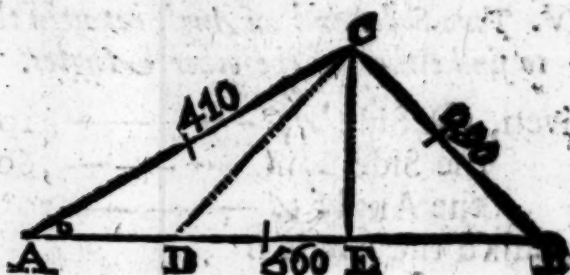
CASE VI. *Three Sides given, to find an Angle.*

Given, the Side AB 560

the Side AC 410

the Side BC 290

Requir'd the Angle at A .



1. Draw AB 560 from A to B ;
2. Take the Side AC 410 in your Compasses, and with one Foot in A draw an Arch at C .
3. With the Side BC 290 in your Compasses, and one Foot in B , cross the said Arch at C .
4. From the crossing of the said Arches to A and B , draw CA and CB , and 'tis done.

The Angle at A measured on the Chords is 30° &c.

SECT

SECT. V.

Plain Sailing Geometrical.

IN laying down all the Cases of Plain Sailing, Traverse, Mercator, &c. observe to make the Top of the Book or Slate North, and the Bottom South; the right Hand East, and the left Hand West, &c.

Observe, that in the Application of right-angled Triangles to Questions of Plain Sailing, the Course is always the Angle at the Base: The Distance is the Hypotenuse: The Difference of Latitude is the North and South Line; and the Departure is the East and West Line of the Triangle.

Thus, in the 4 Triangles below, N^o 1, represents a Course in the N. E. Quarter; N^o 2, a Course in the S. E. Quarter; N^o 3, a Course in the S. W. Quarter; N^o 4, a Course in the N. W. Quarter: And in each of these Triangles the Point *A* represents the Place sail'd from, and the Point *C* the Place sail'd to: and the Angle at *A* is the Course, the Angle at *C* its Complement, the Hypotenuse *AC* the Distance, the Leg *AB* the Difference of Latitude; and the Leg *BC* the Departure, &c.

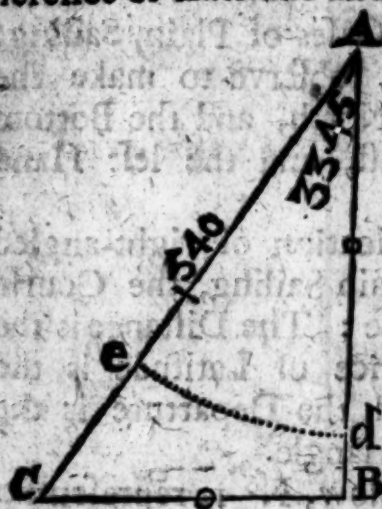


G

CASE

CASE I. *Course and Distance given, to find Difference of Latitude and Departure.*

A Ship sails S. W. by S. 540 Miles, I demand Difference of Latitude and Departure.



1. In this and all other Cases of Plain Sailing, draw the North and South Line AB .

2. The Course being 73 Points from the Meridian, viz. $33^{\circ} 45'$, make the Angle at A $33^{\circ} 45'$ from d to e .

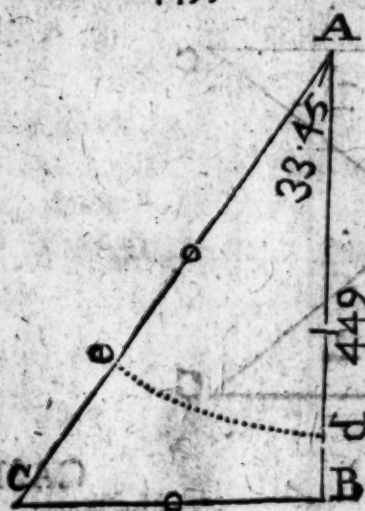
3. Thro' e draw the Hypotenuse (or Distance) AC 540 from A to C .

4. From C let fall a Perpendicular CB , to cut AB in B and 'tis done.

The Difference of Latitude AB measured is 449 and the Departure BC is 300, &c.

CASE II. *Course and Difference of Latitude given to find the Distance and Departure.*

A Ship sails S. W. by S. till her Difference of Latitude be 449, I demand her Distance and Departure



1. Make AB the Difference of Latitude 449, from A to B .

2. Upon B erect the Perpendicular BC at Pleasure.

3. Set off the Course $33^{\circ} 45'$ and draw the Hypotenuse AC to cut BC in C , and 'tis done.

The Distance AC measured will be found to be 540, and the Departure BC measured 300 Miles.

CASE

CASE III. *Course and Departure given, to find the Distance and Difference of Latitude.*

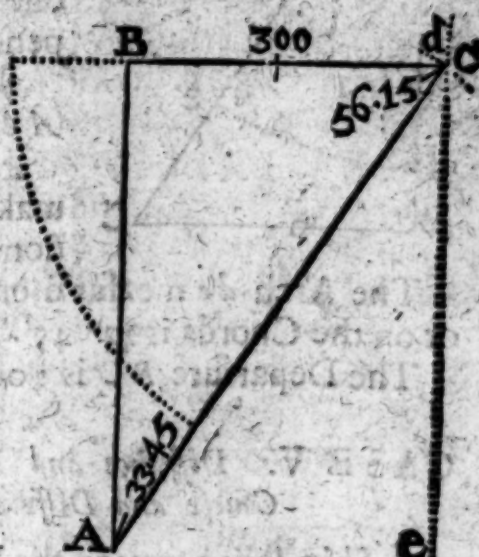
A Ship sails N. E. by N. till her Departure be 300 Miles, her Distance and Difference of Latitude is required.

1. Draw AB at Pleasure.

2. At the Distance 300 the Departure given, draw the parallel Line de .

3. With the Angle of the Course $33^{\circ} 45'$ draw the Hypotenuse AC to cut the Parallel in C .

4. From the crossing at C let fall the Perpendicular CB , to cut AB in B , and 'tis done.



Another Way to lay it down.

1. Draw AB at Pleasure.

2. Upon the North End thereof (because the Ship sails to the Northward) erect the Perpendicular BC , upon which set off the Departure 300.

3. Make the Angle at C $56^{\circ} 15'$ the Complement of the Course, and draw the Hypotenuse CA , to cut AB in A , and 'tis done.

The Distance AC is 540.

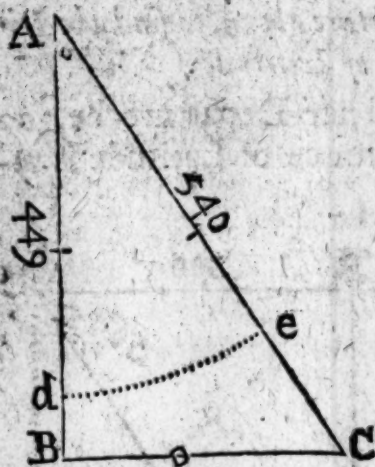
The Difference of Latitude AB is 449.

CASE IV. *Distance and Difference of Latitude given, to find the Course and Departure.*

A Ship sails in the S. E. Quarter 540 Miles, and then finds her Difference of Latitude is 449, her Course and Departure is required.

C 2

1. Make



1. Make the Difference of Latitude AB 449 from A to B , and upon B erect the Perpendicular BC .

2. Take the Distance in your Compasses, and with one Foot in A cross the Perpendicular BC in C .

3. From the crossing C to A draw AC .

4. With the Chord of 60 make the Arch de , and 'tis done.

The Arch de measur'd on the Rumbs is 3 Points, or on the Chords is $33^{\circ} 45'$.

The Departure BC is 300.

CASE V. *Distance and Departure given, to find the Course and Difference of Latitude.*

A Ship sails between the N. and W. 540 Miles, her Departure is 300; I demand her Course, and Difference of Latitude.



1. Draw AB at Pleasure

2. At B erect the Perpendicular BC , and set off the Departure 300 from B to C .

3. With the Distance 540 in your Compasses, and one Foot in C , cross the Line AB in A .

4. From C to the Crossing at A draw AC .

5. With the Chord of 60 and one Foot in A , make the Arch de , and 'tis done.

AB the Difference of Latitude is 449, and the Course de is 3 Points, or $33^{\circ} 45'$.

CASE

CASE VI. *Difference of Latitude and Departure given, to find the Course and Distance.*

A Ship sails in the S. W. Quarter till her Difference of Latitude be 449, and her Departure 300; her Course and Distance is required,

1. Draw the Difference of Latitude AB 449 from A to B .
2. Upon B erect the Perpendicular BC , upon which set off the Departure 300, from B to C .
3. From A to C draw the Hypotenuse AC .
4. With the Chord of 60, make the Arch de , and 'tis done.

The Distance AC is 540, and the Angle at A , the Course three Points, or $33^{\circ} 45'$.



SECT. VI.

Traverse Sailing Geometrical.

TRaverse Sailing is of Use, when a Ship having set Sail from one Port intending for another, whose Course and Distance from the Port sail'd from, given or known; but by reason of contrary Winds, or other Accident, is forced to sail upon several Courses, which are required to be brought into one Course, to know thereby (after so many various Turnings and Windings) the true Course and Distance made good from the Place sail'd from, and

the true Point or Place where the Ship is, that so (the Wind coming fair) it may be known how to shape a Course for the Place intended: and this which is the chief Subject of Traverse Sailing, may be perform'd Geometrically two Ways, both which I shall briefly lay down.

The first is perform'd by drawing new Meridians through the Extremity of every Course, parallel to the first Meridian, or North and South Line, that you make at the first, and so set off every Course with a Sweep of 60, as if it was a Question in Plain Sailing. You may also let fall Perpendiculars to every new Meridian from the Point that the Ship sail'd to upon that Course, and so you have the Course, Distance, Difference of Latitude and Departure, to every Course; and this Method is very useful where the Courses tend generally all one Way, without intersecting one another. But if your Courses frequently cross one another, 'tis best to lay them down without new Meridians, *viz.* to set off one Course by another; for which Mr. *Atkinson* in his *Epitomy* laid down 4 Rules; but they being so burthensom to the Memory of young Learners, I shall not so much name them; but shall lay down one Rule which is universally useful in all Cases, and easily remembered and 'tis this.

Observe how many Points are between the Point next to be laid down, and the Point opposite to the Course last laid down, for that is the Point for laying down; therefore with the Chord of 60, and one Foot in the Point the Ship is last come to, describe an Arch; upon which set off the Points found by the abovesaid Rule, and through that draw the Line for the next Course, &c. I shall explain both Ways by Example; and first,

How to lay down a Traverse by New Meridians.

A Ship bound for a Port distant 120 Miles N. E. $\frac{1}{2}$ E. sails S. S. E. 30 Miles, then N. E. by N. 40, then E. by N. 25, then N. N. E. 44; I demand Course and Distance made good, and also the Course and Distance to the Port bound for.

First, draw the Line KH at Pleasure, for a Meridian, or North and South Line; and therein assume a Point, as at A , for the Port sail'd from; then with 60 of the Chords, and one Foot in A , draw the Arch Lm , upon which set off two Points, (because the Course is S. S. E.) from L to m , and draw the Line Am , upon which set off the Distance 30, from A to B , then is your Ship at B ; then let fall the Perpendicular BK , then is AK $27^{\circ} 7'$. the Difference of Latitude, and BK $11^{\circ} 5'$, the Departure for the first Course—— Then for the second Course with the Distance KB draw the Parallel BN , and thereby, with the Chord of 60, as before, set off the second Course and Distance, N. E. by N. 40, from B to C , and let fall the Perpendicular CL , then is your Ship at C , the Difference of Latitude upon that Course is BL $33:3$: and the Departure CL $22:2$ —— Then proceed in the same manner for the third Course; with the Parallel CO , set off E. by N. 25, from C to D , and draw the Line DP , from which set off the last Course, N. N. E. 44. then is your Ship at E . Now seeing the Ship came from A , and is now at E , the Line AE measured on the same equal Parts, upon which all the other Distances were taken, will be found to be 91 Miles, and the Arch RQ measured on the Rumbs is 5 Points, viz. N. E. by E. so that the Ship is now 91 Miles, N. E. by E. from the Port sail'd from.

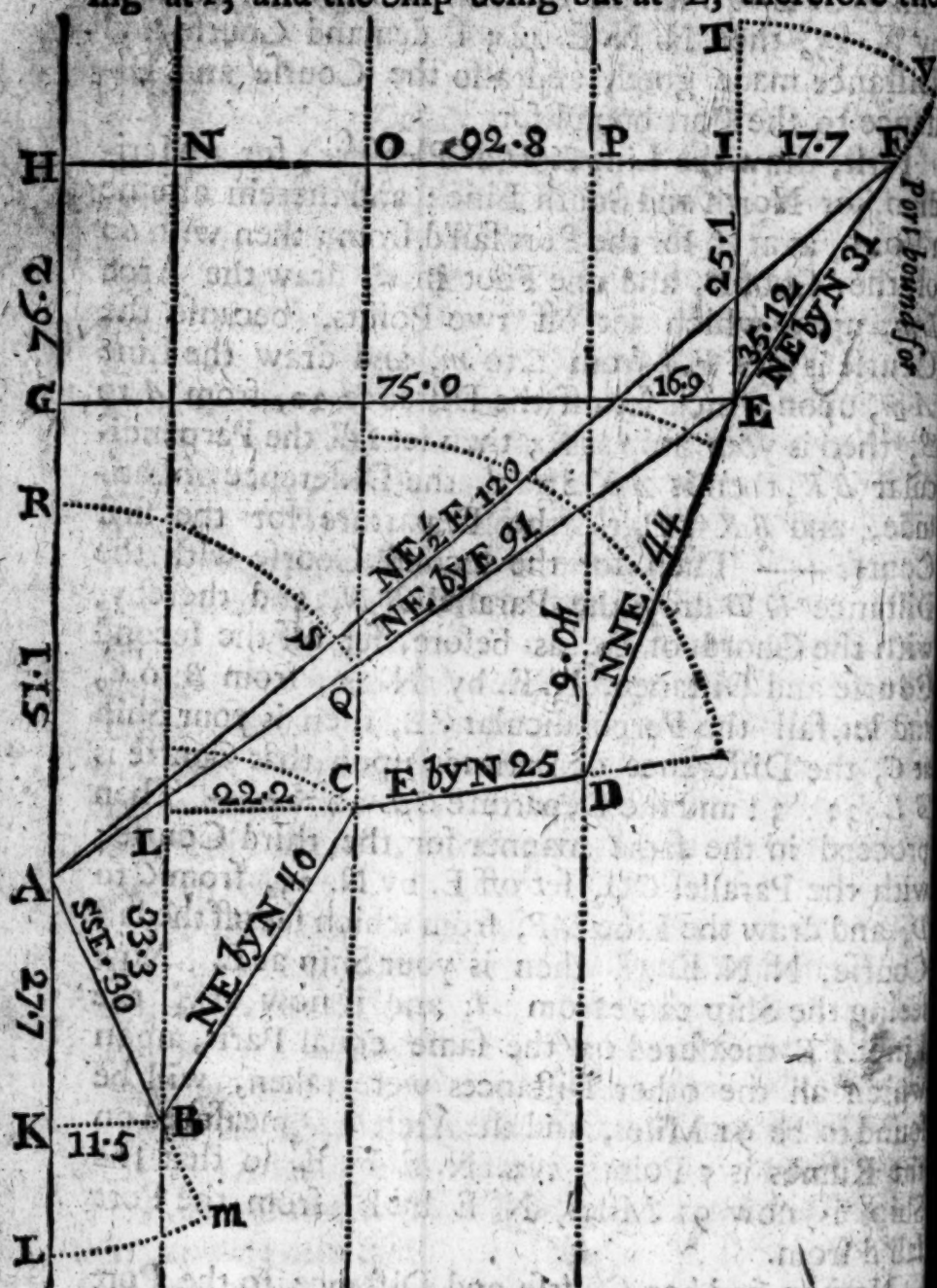
Now to find her Course and Distance to the Port bound for, set off 4 half Points upon the Arch RQ ; from

C 4

from

24 *Traverse Sailing Geometrical.* Chap. I.

from R to S, and from A thro' S draw the Line ASF; upon which set off 120 (the Distance from the Port sail'd from to the Port bound for) from A to F, then is F the Port bound for; now the Port bound for, being at F, and the Ship being but at E, therefore the



Sect. 6. *Traverse Sailing Geometrical.*

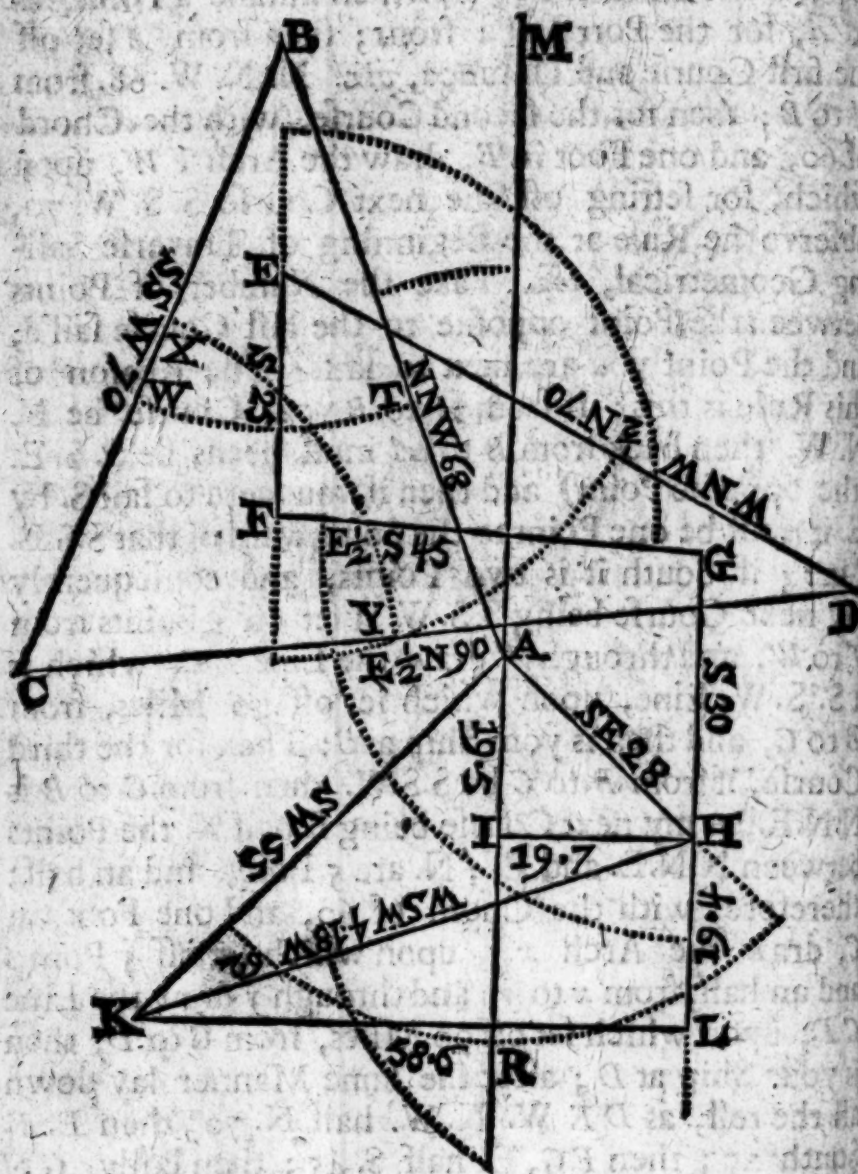
25

Arch *TV* measured on the Chords is $35^{\circ} 12'$, or N.E. by N. somewhat Easterly, &c.

How to lay down a Traverse without New Meridians.

First, Draw a North and South Line, as in the former, as the Line *RM*; in which assume a Point, as at *A*, for the Port sail'd from; then from *A* set off the first Course and Distance, viz. N. N. W. 68. from *A* to *B*; then for the second Course, with the Chord of 60, and one Foot in *B*, draw the Arch *TW*, upon which, for setting off the next Course S. S. W. 70, observe the Rule at the Beginning of Traverse Sailing Geometrical, viz. Take the Number of Points between the Point opposite to the last Course sail'd, and the Point you are next to sail. The Reason of this Rule is this: If from *A* to *B* your Course be N. N. W. then back from *B* to *A* must needs be S. S. E. (the opposite Point) and then if you were to sail S. by E. it must be one Point to the Southward of that S. S. E. Line; if South it is two Points, and consequently my next Course being S. S. W. I set off 4 Points from *T* to *W*, and through *W* draw the Line *BC*, which is a S. S. W. Line, upon which set off 70 Miles, from *B* to *C*, and then is your Ship at *C*: Then for the third Course, if from *B* to *C* be S. S. W. then from *C* to *B* is N. N. E. but my next Course being E. half N. the Points between N. N. E. and E. $\frac{1}{2}$ N. are 5 Points and an half; therefore, with the Chord of 60, and one Foot in *C*, draw the Arch *xy*, upon which set off 5 Points and an half, from *x* to *y*, and through *y* draw the Line *CD*, upon which set off 90 Miles, from *C* to *D*, then is your Ship at *D*; after the same Manner lay down all the rest, as *DE* W. N. W. half N. 70; then *E. F.* South 25; then *FG*, E. half S. 45; then lastly, *GH* South 30, which is the last Course: Then your Ship being at *H*, and the Port sail'd from at *A*, the Line *AH* 28 Miles is the Distance made good, and the Angle at *A* is four Points, viz. S. E. but the Port intended for being S. W. 55. I set it off from *A* to

to K , but the Ship being at H , the Line $H K$ 62 Miles is the Distance from the Ship to the Port bound for, and the Course is found by measuring the Angle at H $71^{\circ} 48'$. or W. S. W. more than 1 Quarter West-erly, &c.



The Question. A Ship at *A* bound for a Port at *K*, which bears S. W. from *A* distant 55 Leagues, but meeting with contrary Winds, she sails N. N. W. 68 Leagues.

sect. 6. *Traverse Sailing Geometrical.*

29

Leagues, then S.S.W. 70 Leagues, then E. half N. 90 Leagues, then W. N.W. half N. 70 Leagues, then S. 25 Leagues, then E. half S. 45 Leagues, then South 30 Leagues; I demand Course and Distance made good, and Course and Distance to the Port bound for.

How to transcribe a Traverse, or any other right-lined Figure, from the Slate to a Book, or from one Book to another.

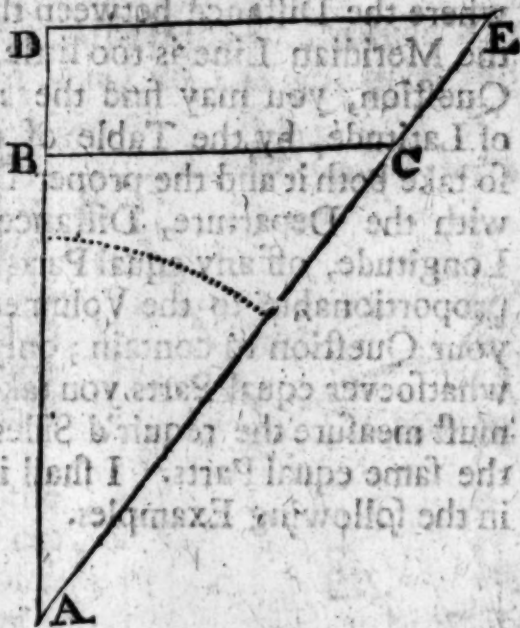
In the first Line RM make 2 or 3 Marks, as at R A and M ; then in the Book in which you would lay it down, draw also the same Line, and take the Distance RA , and set from R to A in the new Draught; likewise set the Distance AM from A to M ; then for laying down the Courses; as first, from A to B , with the Distance AB in the old Draught, and one Foot in A in the new Draught, make an Arch at B ; then with the Distance MB in the old Draught, and one Foot in M , in the new Draught, cross the former Arch at B ; then from A , and the crossing of these Arches, draw the Line AB ; then, for the Line BC , with the Distance RC , and one Foot in R , draw a small Arch, and with the Distance BC , and one Foot in B , (or with the Distance MC , and one Foot in M) draw an Arch to cross the former in C , then from B to that crossing draw the Line BC , and so in the rest of the Courses. And note, you need not regard what two Points you take in the old Draught for the fixed Point of your Compasses, provided you take the same Points in the new Draught, only observe to take two Points, so as that the Arches may fairly cross one another; or else you cannot so well find the Point of Intersection; as supposing you would find the Point B , if you take the Distance AB , and set from A to B , and make an Arch; and then if you take the Distance RB , and set from R to B ,

S E C T. VII.

Mercator's Sailing Geometrical.

Mercator's Sailing is laid down by a right-angled Triangle, as Plain Sailing, only the Triangle hath two Perpendiculars, the shorter representing the Departure, as in Plain Sailing, and the longer is the Difference of Longitude.

Thus in the Triangle annexed, *A* represents the Place sail'd from ; the Angle at *A* is the Course, and the Side *AB* is the proper Difference of Latitude, and *BC* the Departure, as in Plain Sailing. The whole Base *AD* is the Meridional Difference of Latitude, and the Perpendicular *DE* is the Difference of Longitude ;



and seeing the Angle at *A* is common to both Triangles, *ABC*, and *ADE*, therefore the Base *AB* is in Proportion to the Perpendicular *BC*, as the whole Base *AD* is to the Perpendicular *DE* : And hence comes the Proportion ; as proper Difference of Latitude to meridional Difference of Latitude, so is the Departure to the Difference of Longitude. *Euclid. lib. 6. Prop. 4.*

The

The Meridian Line, with the Scale of equal Parts next to it, upon the Scale, are of Use for laying down Questions in Mercator's Sailing; they are the two lowest Lines upon the Scale, the Meridian Line marked (Merid.) and the equal Parts marked [Eq. P.] the Graduation of the Meridian Line increases, and the Degrees of Latitude grow bigger near the Poles the Distance and proper Difference of Latitude may be taken off the equal Parts, and the meridional Difference of Latitude off the Meridian Line, if the Question be so large as to permit it. Nevertheless, in small Questions, and short Distances where the Distance between the two Latitudes upon the Meridian Line is too little, to make a handsome Question, you may find the meridional Difference of Latitude, by the Table of meridional Parts, and so take both it and the proper Difference of Latitude with the Departure, Distance, and Difference of Longitude, off any equal Parts that you think will be proportionable to the Volumes that you would have your Question to contain; only take Care, that from whatsoever equal Parts you take the given Sides, you must measure the requir'd Sides (when found) upon the same equal Parts. I shall instance in both Ways in the following Examples,

CASE

CASE I. One Latitude, Course and Distance given, to find the other Latitude and Difference of Longitude.

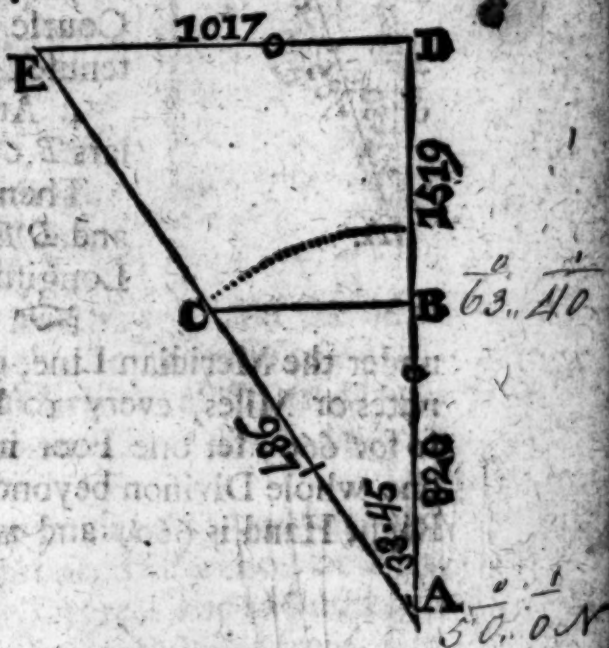
A Ship in Latitude $50^{\circ} 0'$ North, sails N. W. by N. 987 Miles, I demand the Latitude come to, and Difference of Longitude.

1. Draw $A B D$ at Pleasure.
2. At an Angle of $33^{\circ} 45'$ draw $A C$ continued, upon which from the equal Parts set off the Distance 987, from A to C .
3. Let fall the Perpendicular $C B$.
4. Measure $A B$ the Difference of Latitude 820 min. or $13^{\circ} 40'$. which added to Lat. 50, gives the Latitude come to, $63^{\circ} 40'$.
5. Extend the Compasses upon the Meridian Line from 50 to $63^{\circ} 40'$ and set that Extent upon the Line $A D$, from A to D ; then is $A D$ 1519, the meridional Difference of Latitude.

6. From D erect the Perpendicular $D E$, to cut $A C E$ in E , and 'tis done.

Then is $A B$ 820 min. or $13^{\circ} 40'$ the Difference of Latitude, which added to the Latitude sail'd from (because the Ship sails to the Northward) produces $63^{\circ} 40'$. the Latitude come to.

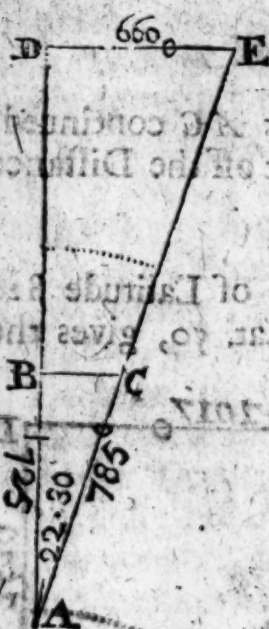
$D E$ 1017 is the Difference of Longitude required.



CASE

CASE II. Both Latitude and Course given, to find the Distance and Difference of Longitude.

A Ship in Lat. $56^{\circ} 25'$ North, sails N. N. E. in Latitude $68^{\circ} 30'$. I demand as above.



1. Extend the Compasses on the Meridian Line from Lat. $56^{\circ} 25'$ to Lat. $68^{\circ} 30'$. and set that Extension on the Line AD , from A to D .

2. Take 725 (the proper Difference of Latitude in Minutes) from the equal Parts under the Meridian Line, and set upon the Line AD , from A to B .

3. At an Angle of $22^{\circ} 30'$ (the Course given) draw the Hypotenuse ACE .

4. At B and D erect Perpendiculars BC and DE , and 'tis done.

Then is AC 785 the Distance and DE 660 is the Difference of Longitude required.

Note, Upon the equal Parts under the Meridian Line, every Degree being 60 Minutes or Miles, every 10 Degrees is 600 Miles; and so for 660, set one Foot in 10, the other extended one whole Division beyond the Cypher towards the Right Hand is 660, and 2 Divisions is 720, &c.

CASE

CASE III. One Latitude, Course, and Difference of Longitude given, to find the other Latitude and Distance.

A Ship in Lat. 50 sails N.N.W. till her Difference of Longitude be 7 Deg. or 420 Minutes. I demand as above.

1. Draw ABD at pleasure.
2. At an Angle of $22^{\circ} 30'$ draw the Hypotenuse AC continued.
3. At the Distance of 420 (the Difference of Longitude) draw the Line $g b$ parallel to AD.
4. From the Point where that Parallel intersects the Hypotenuse, as at E, let fall the Perpendicular ED.
5. With the Extent AD, and one Foot in the given Latitude go upon the Meridian Line, extend the other upward, because the Ship sails to the Northward, and the other Foot will light upon $59^{\circ} 40'$, the Latitude come to.
6. With the proper Difference of Latitude 580 (off the equal Parts) and one Foot in A, find the Point B in the Line ABD.
7. At D erect the Perpendicular BC, and 'tis done. Then is AB 580 the proper Difference of Latitude, which reduced into Degrees and Minutes, is $9^{\circ} 40'$, which added to the Latitude sailed from, viz. $50^{\circ} 00'$, the Sum $59^{\circ} 40'$ is the Latitude come to, and AC 628 is the Distance required.



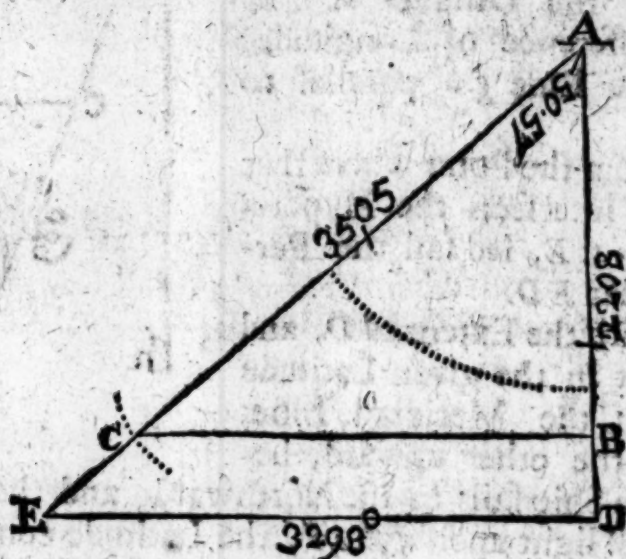
D

CASE

CASE IV. Both Latitude and Distance given, to find the Course, and Difference of Longitude.

A Ship in Latitude 50° North, sails 3505 Miles, and is then by Observation in Lat. $13^{\circ} 12'$. I demand as above.

This Question being larger than the Book can conveniently contain, if taken off the Meridian Line, I shall take it off a Scale of lesser equal Parts, and find Meridional Difference of Latitude by the Table.



1. Draw ABD , upon which set off the proper Difference of Latitude 2208 from A to B , and the Meridional Difference of Latitude 2676, from A to D .

2. At B and D erect the Perpendiculars BC and DE .

3. With the Distance 3505, and one Foot in A , with the other cross the Perpendicular BC in C .

4. Draw AC continued to E , and 'tis done.

The Angle BAC measured on the Chords is $50^{\circ} 57'$, and the Difference of Longitude DE 3298, is the Difference of Longitude required.

CASE

CASE V. *Both Latitude and Departure given, to find Course, Distance, and Difference of Longitude.*

A Ship in Latitude 55° North sails in the North East Quarter into Latitude $56^{\circ} 10'$ North, her Departure 50 Miles. I demand as above.

This and all the following Questions in *Mercator's Sailing Geometrical* are too short Distances to be taken off the Meridian Line, I shall therefore project them from larger equal Parts.

1. Draw the Line ABD , upon which set off the proper Difference of Latitude 70 from A to B , and the Meridional Difference of Latitude 124 from A to D .

2. From the Points B and D erect the Perpendiculars BC and DE .

3. Upon BC set off the Departure 50 from B to C .

4. Thro' the Point C draw the Line AC , continued till it cut the Perpendicular DE in E , and 'tis done.

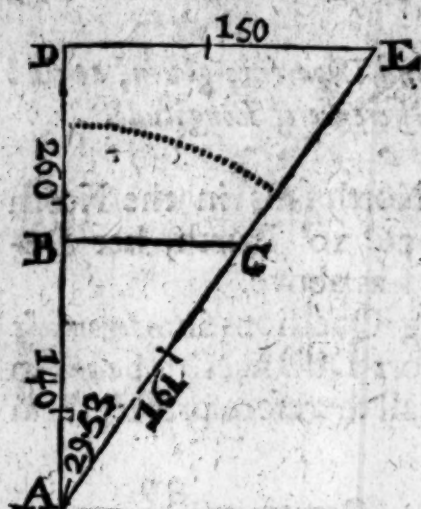
Then the Angle at A measured on the Chords, is $55^{\circ} 32'$ for the Course, which is N. E. by N. something Easterly, and the Hypotenuse AC 86 is the Distance, and the Perpendicular DE 89 is the Difference of Longitude required.

**CASE VI.** *Both Latitudes and Difference of Longitude given, to find the rest.*

Suppose 2 Places, one in Latitude $56^{\circ} 15'$, and the other in Latitude $58^{\circ} 35'$, their Difference of Longitude $2^{\circ} 30'$; I demand the Course from the Southermost to the Northermost, and also their Distance and Departure.

D 2

1. Upon



1. Upon the Line ABD set off the proper Diff. Lat. and Merid. Diff. Lat. to B and D , and there erect Perpendiculars, as in Case the Fifth.

2. Upon DE set off the Difference of Longitude 150 from D to E .

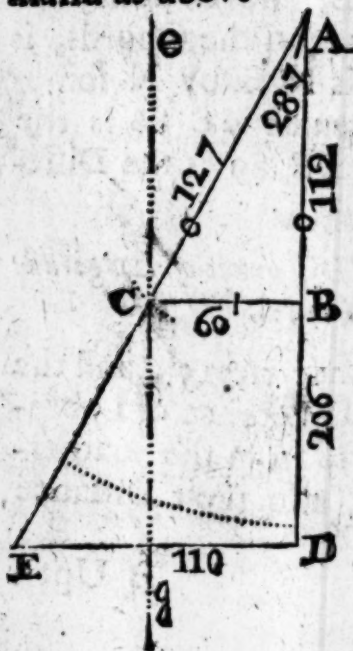
3. From A to E draw the Hypotenuse ACE to cut BC in C . Then is

BC 80 the Departure; the Angle at A $29^\circ 53'$ is the Course, and AC 161 is the Distance.

Note, The Figure placed between B and D (as here is 260) is the Meridional Difference of Latitude represented by the whole Line AD .

CASE VII. One Latitude, Course and Departure given, to find the other Latitude, Distance, and Diff. Longitude.

A Ship in Latitude $58^\circ 00'$ North sails S.S.W. $\frac{1}{2}$ W. till her Departure be 60 Miles or Minutes; I demand as above.



1. Draw ABD at pleasure.

2. At an Angle of $28^\circ 7'$, the given Course, draw ACE continued.

3. At 60 Distance from ABD draw the Parallel eg , and where it cuts ACE , as in C , let fall the Perpendicular CB .

4. Then is AB the proper Difference of Latitude, by which you may find the Latitude, Course, and also the

Sect. 7. *Mercator's Sailing Geometrical.* 37

the Meridional Difference of Latitude, which (found as directed in *Mercator's Sailing Trigonometrical*, Case the first) is 206, which set from A to D .

5. Raise the Perpendicular DE to cut ACE in E , and 'tis done.

The Latitude come to is $56^{\circ} 8'$, the Diff. Long DE 110, &c.

CASE VIII. *One Latitude, Distance, and Departure given, to find the other Latitude, Course, and Difference of Longitude.*

A Ship in Lat. $58^{\circ} 00'$ N. sails between the South and West 127 Miles, her Departure 60; I demand the rest.

See the Figure in Case the seventh.

1. Draw ABD at pleasure.

2. At 60 (the Departure) Distance from ABD , draw the Parallel eg .

3. With the Distance 127, and one Foot in A cross the said Parallel in C .

4. Let fall the Perpendicular CB to cut ABD in B ; then is AB the proper Diff. Latitude, by which find the Meridional Difference of Latitude, as in Case VII. which set from A to D , and raise the Perpendicular DE .

5. From A through the Crossing at C , draw ACE , to cut DE in E , and 'tis done.

The Latitude come to is $56^{\circ} 8'$, the Angle A the Course $28^{\circ} 7'$.

The Difference of Longitude DE is 110.

S E C T VIII.

Parallel Sailing Geometrical.

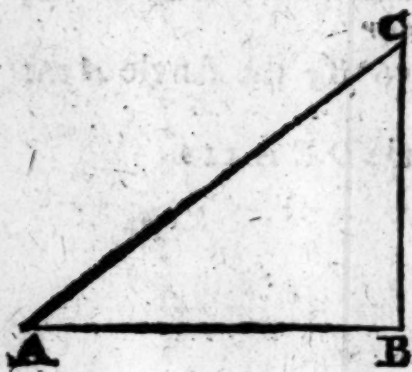
THERE are only two ways most useful and intelligible for laying down *Parallel Sailing*; the one called *Bell-fashion*; the other *Plain Triangle*.

In the first of these it is laid down by a Figure somewhat like a Bell, from whence I suppose it takes its Name. In this Figure the two Sides AD and AE are equal (*viz.* equal to the Radius or Sine of 90 ; or if you think the Projection will be too small, you may make them twice the Sine of 90 , provided you also take all the other double also) and then the Line BC represents their true Distance in the Parallel,



and DE represents their Distance in the Equinoctial, or Difference of Longitude.

The other Way is by Plain Triangle, in which



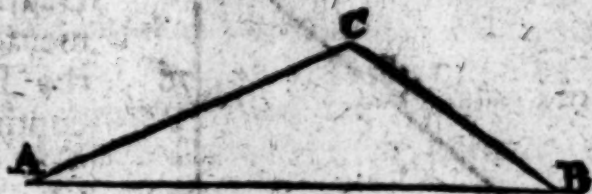
2 of the Angles are equal to the Complement of the Latitude in which their Distance is required; and therefore if their Difference of Longitude, or Distance in the Equinoctial, be given or required, the Triangle is Right-angled, as in the Margin;

and there the Angle at A is equal to the Complement of Latitude, the Perpendicular

pendicular BC represents the Distance, and the Hypotenuse AC , the Difference of Longitude.

But when the Distance in one Parallel is given, and the Distance in another Parallel required, it makes an oblique Triangle, *viz.* with 2 Acute Angles (because the Complement of all Latitudes, except Latitude $00^{\circ} 00'$, *viz.* under the Equinoctial, is less than 90 Degrees) as

in the Margin, wherein the Angle at A represents the Complement



of one Latitude, and its opposite Side BC their Distance in that Parallel; and the Angle at B is equal to the Complement of the other Latitude, and its opposite Side AC represents their Distance in that Parallel, supposing each Ship keeps always under the same Meridian; and this by oblique Triangle is useful only in the two last Cases.

CASE I. Two Ships on Places in one Parallel, their Latitude and Distance given, to find their Difference of Longitude,

Two Ships in Lat. 50 , distant 76 Miles; I demand as above.

1. With the Sine of 90 (or Chord of 60) and one Foot in A , sweep the Arch DE .

2. With the Sine of 40 (the Complement of Latitude) and one Foot in A , sweep the Arch BC .

3. Take the Distance 76 from any equal Parts, and set from B to C , and draw the Line AE through the Point C , to cut the Arch DE in E , and draw AD through B .

D 4

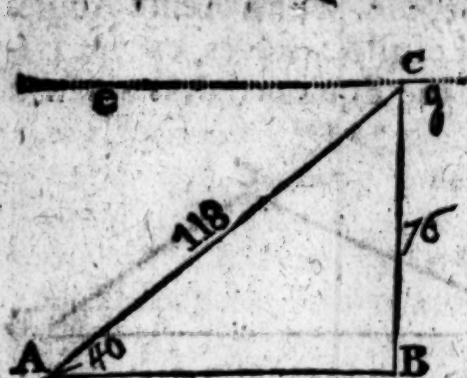
Bell-fashion.



4c Draw

4. Draw the Lines BC and DE , then is BC 76 the Distance, and DE 118 the Difference of Longitude.

The same Question by plain Triangle:



1. Draw the Line AB at pleasure.

2. At an Angle of 40 Degrees, the Complement of Latitude, draw the Hypotenuse AC continued.

3. Draw the Parallel eg distant from AB , 76 the Distance.

4. Where that Parallel intersects the Hypotenuse AC , as in the Point C , let fall the Perpendicular CB to cut AB in B , and 'tis done.

Then is BC the Distance 76, and AC 118 the Difference of Longitude.

CASE II. *Latitude and Difference of Longitude given to find the Distance.*

Two Ships in Latitude 50, their Difference of Longitude 118; I demand their Distance.

See the Figures in Case I.

Bell-fashion.

1. With the Sine of 90 Draw the Arch DE , and with the Sine of 40, the Complement of Latitude, draw the Arch BC , as in Case the first.

2. Set the Difference of Longitude 118, from D to E .

3. Draw the Lines AD and AE , which will cut the

By Plain Triangle.

1. Draw AB at pleasure.

2. With 40 Degrees the Complement of Latitude, make the Angle at A , and draw the Hypotenuse AC , upon which set off the Difference of Longitude 118 from A to C .

3. From C let fall the Perpendicular CB to cut

q. 8. *Parallel Sailing Geometrical.*

41

Arch BC in B and C .

AB in B , and 'tis done.

4. Draw also the Lines AC and DE , and 'tis done.

Then is BC 76 the Distance required.

The Line BC 76 is the Distance required.

ASE III. *Distance and Difference of Longitude given, to find the Parallel or Latitude.*

A Ship sails due West 2700 Miles, her Difference Longitude 4200 Min. I demand what Latitude the Ship sails in.

1. With the Sine of 90, and one Foot in A , draw the Arch DE .

2. Set the Difference Longitude 4200 from D to E , and draw the Line DE .

3. Draw the Lines BD and AC .

4. Bisect the Line DE in m , and draw the Line Am .

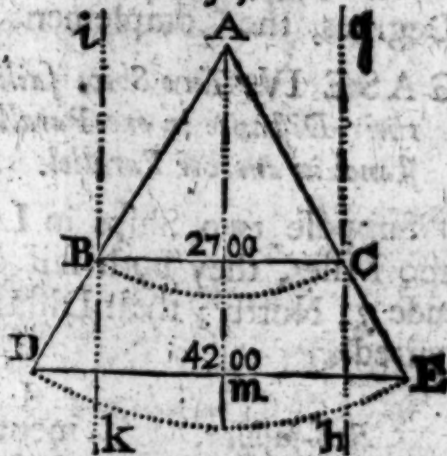
5. Draw the Lines ik

and gb parallel to Am , and distant from Am equal to half the given Distance 1350.

6. Where these Parallels cross the Lines AD and AE , with the fixed Point of your Compasses in A draw the Arch BC , and then draw the Line BC .

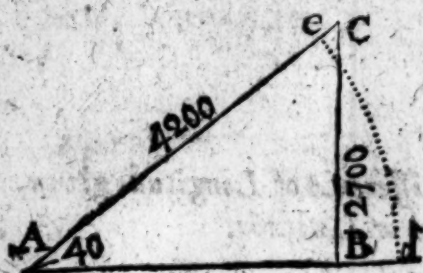
Then place one Foot in A , and the other in B or C , that Extent applied to the natural Sines will reach to 40, the Complement of Latitude; so that 50 is the Latitude required.

Bell-fashion.



By

By Plain Triangle.



1. Draw AB continued.

2. Any where, as at B , erect the Perpendicular BC , and set off the Distance 2700 from B to C .

3. With the Difference of Longitude 4200, and one Foot in C cross the Line AB in A , and draw the Line AC .

4. With the Chord of 60, and one Foot in A draw the Arch de .

The Angle at A measured on the Arch de , is 40 Degrees, the Complement of Latitude required.

CASE IV. *Two Ships sailing directly North or South their Distance in one Parallel given, to find their Distance in another Parallel.*

Suppose two Ships in Latitude 50 North, distant 200 Miles, they both sail directly North into Latitude 73 North; their Distance in that Parallel is required.

Bell-fashion.



1. With the Sine Complement of the Latitude in which their Distance is given (viz. Sine Complement of 50, which is Sine of 40) and one Foot in A , describe the Arch DE , and upon that set off the Distance in that Parallel 200 from D to E .

2. With the Sine of 90 draw the Arch FG .

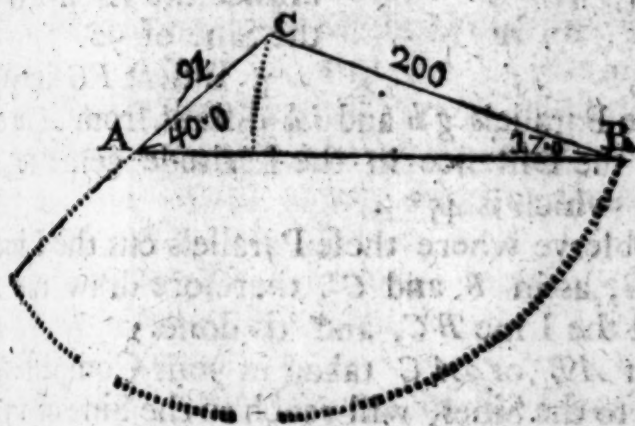
3. From A through D and E draw the Lines AF and AG .

4. With the Sine Complement of the other Latitude

73 (which is the Sine of 17) and one Foot in A , draw the Arch BC to cut AF in B , and AG in C , draw BC .

The Line BC measured on the same equal Parts in which you took the first Distance DE , will be found to be 91, the Distance of the Ships in Latitude; and if their Difference of Longitude were required, it may be found by measuring the Line FG .

By Plain Triangle.



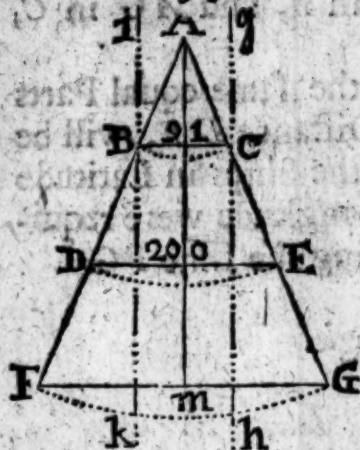
Here is given the Angles A and B , the Complement of each Latitude, and the Side BC their Distance in Latitude 50, to find their Side AC their Distance in Latitude 73: So that here is two Angles and a Side opposite to one of them given, to find the Side opposite to the other, by Case I. of *Oblique Plain Angles*, to which I refer you.

SE V. Two Ships in one Parallel, with their Distance in that Parallel given, sailing both directly North and South, and then their Distance in the Parallel come to be given, to find the Parallel come to.

Two Ships in Latitude 50, distant 200 Miles, sail North till they are but 91 Miles distant; I demand what Latitude come to.

Bell.

Bell-fashion.



1. With Sine Comp. 50, and one Foot in draw the Arch DE, set off 200 from D to being the given Distance in that Parallel.

2. Through D from Point A draw the Line AF, and from A through E draw AG, having drawn the Arch FG with the Sine of 90.

3. Bisect FG in m,

draw the Parallels gb and ik distant from A m equal to half the Distance in the Latitude come to, or half 91, which is $45^\circ \frac{1}{2}$.

4. Observe where these Parallels cut the Line AF and AG , as in B and C ; therefore draw the Line BC and the Line BC , and 'tis done.

Then AB or AC taken in your Compasses, and applied to the Sines, will reach to the Sine of 17, Comp. of the Latitude required; so that the Latitude come to is 73.

By Plain Triangle. See the Triangle in Case IV. which there is given the Side BC 200, their Distance in Latitude 50, and the Angle opposite, viz. 20 the Complement of that Latitude: There is also given the Side AC , their Distance in the Latitude come to, to find the Angle at B the Complement of the Latitude come to; so that here are two Sides and an Angle opposite to one of them given, to find the Angle opposite to the other by Case II. of *Obl. Plain Trigonometry Geometrical.*

SECT. IX.

Middle Latitude Sailing Geometrical.

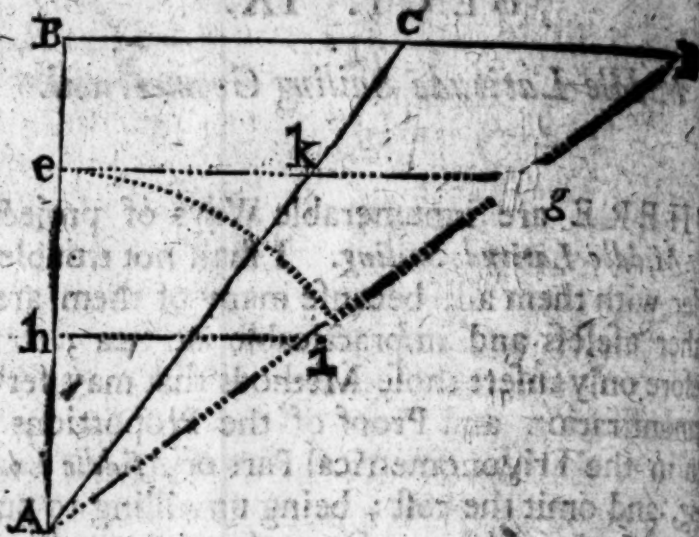
THERE are innumerable Ways of projecting *Middle Latitude Sailing*. I shall not trouble the Reader with them all, because many of them are altogether useless and impracticable at Sea; I shall therefore only insert those Methods that may serve as Demonstration and Proof of the Proportions laid down in the Trigonometrical Part of *Middle Latitude Sailing*, and omit the rest; being unwilling to put the Reader to the Charge of any thing, but what may be useful and profitable.

The first Proportion mentioned in *Middle Latitude Sailing Trigonometrical*, is, As Difference of Latitude to Difference of Longitude, so Sine Complement of Middle Latitude to the Tangent of the Course. Or (which is the same) as Difference of Latitude to Sine Complement of Middle Latitude; so Difference of Longitude to the Tangent of the Course.

The first Question there, is in Case I. *One Latitude, Course and Distance given, to find the other Latitude, Departure and Difference of Longitude.*

A Ship in Latitude $50^{\circ} 00'$ North, sails N. E. by N. 7 Miles; I demand the Latitude come to, with Departure, and Diff. of Longitude.

Note, I shall instance, in this Question, Examples of all the different Ways that I shall insert for projecting *Middle Latitude Sailing*, and for demonstrating the Proportions generally used therein, supposing it too tedious to insert all the different Proportions and Demonstrations in every Case thereof, and first for the Proportion above mentioned.

Geometrical Construction.

Draw the North and South Line AB , and the given Course and Distance lay down the Triangle ABC , as in *Plain Sailing Geometrical*, Case I. thus having found the Difference of Latitude, consequently the Latitude come to, and Middle Latitude; set off the Sine of the Complement of Middle Latitude from A to b , and set off the Radius, or Sine 90, from A to e , and erect the Perpendiculars be and eg parallel to BC , and continue BC at pleasure. Then observe where the Hypotenuse AC cuts Perpendicular eg (which is erected from the Sine 90) as in k ; then take in your Compasses the Extent ek , and place from b to i , and from A through i draw the Line AD to cut the Perpendicular BD ; then is BD 1003 the Difference of Longitude required, and BC 548 is the Departure, and AB 987 is the Difference of Latitude, the Hypotenuse AC 987 the Distance, and the Angle BAC $33^{\circ} 45'$ is the Course from the North Eastwards, or N.E. by N.

Now that this is a demonstrative Proof of the Analogy or Proportion before mentioned, is evident; as AB the Difference of Latitude to Ab the Sine Complement

Ex. 9. Middle Latitude Sailing Geometrical. 47

ment of Middle Latitude, so is BD the Difference Longitude to bi , which by Construction is always equal to ek the Tangent of the Course: And that it is As AB to Ab , so BD to bi , see *Euclid. lib. 6.*

P. 4. Therefore as Difference of Latitude to Sine Complement of Middle Latitude, so Difference of Longitude to Tangent of the Course.

Another Proportion is, As Sine Complement of Middle Latitude to Radius, so is Departure to the Difference of Longitude, which may easily be proved and demonstrated in one right-angled Triangle; to which if we prefix another right-angled angle, which is common in *Plain Sailing* (*viz.* as Sine to the Distance, so is Sine of the Course to Departure) making the Perpendicular, which is Departure common to both, you will thereby be constituted an oblique Triangle, whose Proportions between its opposite Sides and Angles plainly gives the third Proportion, *viz.* As Sine Complement of Middle Latitude to the Sine of the Course, so the Distance to the Difference of Longitude: (which is the same) As Sine Complement of Middle Latitude to the Distance, so is the Sine of the Course to the difference of Longitude. I shall illustrate in the first Case before mentioned, where one Latitude, Course and Distance is given, to find the other Latitude, Departure, and Difference of Longitude.

A Ship in Latit. $50^{\circ} 00'$ sails N. E. by N. 987 Miles; I demand as above.

With



With the Course 33° and Distance 987, lay down the Triangle ABC , as *Plain Sailing*, Case I. and having found the Difference of Latitude, and consequently Middle Latitude, which in this Question is 56° therefore draw the Line CD to make an Angle of 56° with the Line CB , and draw the said Line CD till it cut the Line AB continued then is CD 100; the Difference of Longitude required. Because if the Angle BCD be the Middle Latitude, the Angle BDC must

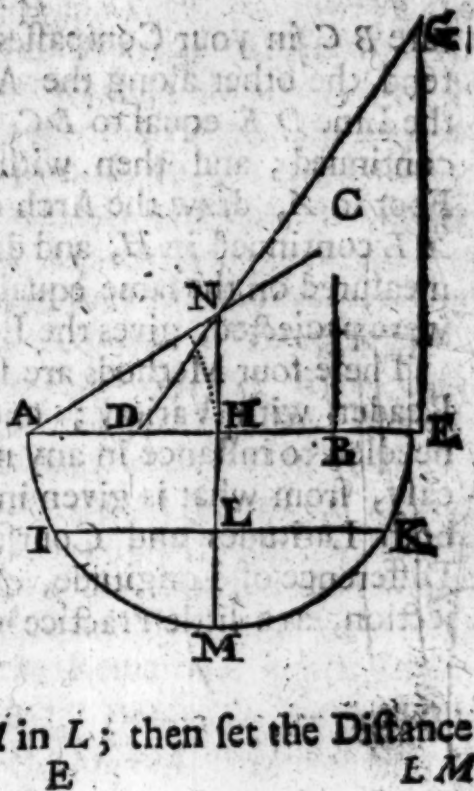
needs be the Complement of Middle Latitude, because DBC is a Right-Angle: And the Side BC being the Departure, is common to both Triangles; therefore as in the Triangle ABC it is as the Radius AB to Distance AC , so is Sine of the Course BAC to Departure BC ; and then it must needs be also, As Sine of BDC , the Complement of Middle Latitude, to opposite Side BC the Departure, so is Radius DB to the Difference of Longitude DC .

Hereby is also projected by consequence a Demonstration of that Proportion, As Sine Complement of Middle Latitude to the Distance, so Sine of the Course to the Difference of Longitude: Or, as it is expressed in the Beginning of *Middle Latitude Sailing Trigonometrical*, As Sine Complement of Middle Latitude to Sine of the Course, so is the Distance to the Difference of Longitude. For by these two right-angled Triangles, with one Perpendicular common to both, constituted the oblique Triangle ACD , in which Angle DAC is the Course, and its opposite Side

the Difference of Longitude, and the Angle ADC is Complement of Middle Latitude, and its opposite Side AC is the Distance; and hence it must needs follow by the known Proportion of Sides to their opposite Angles, and the contrary, that as Sine of ADC to AC , so Sine of DAC to DC : Therefore as Sine Complement of Middle Latitude to the Distance, so Sine of the Course to Difference of Longitude.

These Methods of projecting Middle Latitude being the most demonstrative Proofs of the Analogies or Proportions generally made use of in the Trigonometrical or Arithmetical Calculation thereof, and therefore the most useful, I shall add one or two more, though there are almost infinite Methods for doing; as one Way that is commonly used is by Semicircle, a Way very much in Practice, in which I shall instance in the foregoing Case. A Ship sails from Lat. $50^{\circ} 00'$ North, and sails N.W. by N. 987 Miles; demand the Latitude come to, with Departure and Diff. of Longitude.

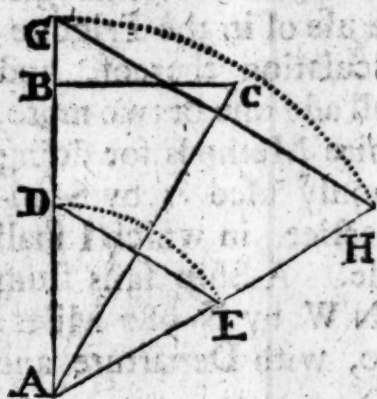
With the Chord of 90° , and one Foot in Compass, draw the Semicircle ME , and at one end thereof, as at A , take an Angle of 33° , the Course given, and lay down the Triangle ABC , with the Course and Distance, as in *Plain Sailing*; and having found the Middle Latitude, which in this Question is 56° , set off the Chord thereof both Ways, from M to I and K , and draw IK to cut HM in L ; then set the Distance



50 *Middle Latitude Sailing Geometrical.* Chap.

LM from A to D , and from B to E , and continue the Line MH till it cut the Line AC , as in N ; then from E erect the Perpendicular EG , and from N draw DG to cut EG in G ; then is BC the Difference of Longitude, BC the Departure, AB the Distance, AB the Difference of Latitude, and the Angle CAB the Course.

Another Projection of the same Question.



With the given Course and Distance lay down the Triangle ABC , as in Plain Sailing, Case I. and having found the Middle Latitude, as before set off the Sine of the Complement of Middle Latitude upon the Line AB , from A to D , and sweep the Arch DE ; then with the Departure

BC in your Compasses, and one Foot in D , extend the other along the Arch DE to E , and draw the Line DE equal to BC , and through E draw a Line continued; and then with the Sine of 90 , and one Foot in A , draw the Arch GH , till it cut the Line AE continued in H , and draw the Line GH , which measured on the same equal Parts from which the Line AB was projected, gives the Longitude required.

These four Methods are sufficient to entertain the Reader with Variety; and I suppose it altogether needless to instance in any more Cases; it being very easy, from what is given in any other Case, whether both Latitudes and Course, or both Latitudes and Difference of Longitude, &c. to make the same Projection, as a little Practice will make evident.

CHAP. II.

Navigation Trigonometrical.

SECT. I.

Plain Trigonometry.

IN the Solution of all plain Triangles, whether right-angled or oblique, there are always three things given to find a fourth, supposing the Radius in right-angled Triangles to be always given or known; which three given Terms are always the first in the Proportion, and the required Term is always the fourth or last; and they are always to be placed in such an Order, that the Proportion may be, the first Term to the second, so the third to the fourth: and before the admirable Invention of Logarithms, the Method was, as in other Cases in the Rule of Three, to multiply the two last Numbers by each other, and divide the Product by the first Number, and the Quotient was the Answer to the Question; but by the Help of Logarithms the Work is much facilitated: For having set down the Numbers in their proper Order, and their Logarithms against them, as you see in the following Examples in *Plain sailing*, you have no more to do, but add the two last Logarithms of the three that are given, and from their sum subtract the first, the Remainder is the Logarithm of the fourth Number required. And again, observe in any three given Terms, where the Radius is

E 2

the

52 *Plain Trigonometry by Logarithms.* Chap. 2.

the first Term, you need but add the two last together, and from the Sum abate 1 towards the Left Hand, and the Remainder is the Logarithm of the fourth Number required. But if Radius be the second or third Term, place 1 on the Left Hand of the said third or second Term, not Radius, and from that Sum subtract the first Term, the Remainder is the Logarithm of the fourth Term required. But if none of the Terms be Radius, as it frequently happens in oblique plain Triangles, but that every Term be the Logarithm, Sine or Tangent of some intermediate Degree or Number; then instead of the Logarithm of the first Term, whether Number, Sine or Tangent, &c. take its Complement Arithmetical, which is done thus: Begin at the Left Hand, and subtract each Number from 9, and set down the Remainder, till you come at the Figure next the Right Hand, which subtract from 10, and set down the Remainder, as before. This Number thus found is called the Complement Arithmetical of the Logarithm from whence it was taken, and is to be set down against the first Term, instead of the Logarithm it self, and the Logarithms of the second and third Terms in their proper Order under it; which being done, add up all the three Sums together, and from their Sum subtract the Radius or 10 towards the Left Hand, the Remainder is the Logarithm of the fourth Term sought.

Plain Trigonometry right-angled.

CASE I. *Hypotenuse and one acute Angle given (consequently both) to find a Leg. See Plain Trigonometry Geometrical, Case I.*

Given { Hypotenuse — 550 } Required AB and
 { The Angle at A $35^{\circ} 0'$ } BC .

1. Making the Hypotenuse Radius, the Leg BC is the Sine of the Angle at A , and the Leg AB is the Cosine.

Sect. 1. *Plain Trigonometry by Logarithms.* 53

Complement of the said Angle, by the Explanation of Axiom the first; therefore the Proportion is, As the Radius to the Hypotenuse, so the Sine Complement of the Angle at A , to the Leg AB .

Again, As the Radius to the Hypotenuse, so the Sine of the Angle at A to the Leg BC .

2. Making the Base Radius, the Perpendicular BC is the Tangent of the Angle at the Base, and the Hypotenuse the Secant of the said Angle. By Explanation of Axiom the first therefore the Proportion is, As the Secant of the Angle at A to the Hypotenuse, so is the Radius to the Leg AB .

Again, As the Secant of the Angle at A to the Hypotenuse, so is the Tangent of the said Angle at A to the Leg BC .

Note, Making the Perpendicular Radius, is the same as making the Base Radius, the Hypotenuse still continuing to be a Secant.

In this Part I have purposely omitted the Operations by Logarithms, they being inserted at large in *Plain and Mercator's Sailing*, which is the Application of *Plain Trigonometry* to *Navigation*; but the Things given and required are the same in both: For whereas in Case I. of *Plain Trigonometry Right-angled*, there is given the Angles and Hypotenuse to find a Leg, so in *Plain Sailing*, Case I. there is given the Course (which is the Angle at the Base) and consequently its Complement (the other acute Angle) and the Distance (which is the Hypotenuse) to find either Leg or both (which are Difference of Latitude and Departure) and the Rules for Calculation are the same.

Case II. Given the Angle at A , and a Leg AB , to find the Hypotenuse. See *Plain Trigonometry Geometrical*, Case II.

1. Making the Hypotenuse Radius, the given Leg AB will be the Sine Complement of the Angle at A , by the

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Explanation of Axiom the first; therefore, As Sine Complement of the Angle at A to the Base, so is Radius to the Hypotenuse.

2. Making the Base Radius, the Hypotenuse is Secant of the Angle at A ; therefore, As Radius to the Base, so Secant of the Angle at A to the Hypotenuse.

CASE III. *Given the Angles and a Leg, to find the other Leg.* Given the Leg AB , as before; required the Leg BC .

Note, Each Case here always refers to the same Case in *Plain Trigonometry Geometrical*, both in right angled and oblique.

1. Making the Hypotenuse Radius, the given Leg is Sine Complement of the Angle at A , and the required Leg BC is the Sine of the same Angle; therefore, As Sine Complement of the Angle at A to Leg AB , so Sine of the Angle at A to the Leg BC .

2. Making the Base Radius, the Leg BC is the Tangent of the Angle at A ; therefore, As Radius to Leg BA , so Tangent of the Angle at A to the Leg BC .

Note, Both these Cases, the second and third, are contained in Case II. of *Plain Sailing*, where the Angles and a Leg (*viz.* Course and Difference of Latitude) are given to find the Distance (which is the Hypotenuse) by Case the second, and the other Leg (which is the Departure) by Case the third. These are also both comprehended under the third Case of *Plain Sailing*, there being also the Angles and a Leg given, *viz.* Course and Departure, to find Distance and Difference of Latitude.

CAS

CASE IV. Given the Hypotenuse and a Leg, to find an Angle. Given Hypotenuse AC and Leg AB , required $\angle BAC$.

1. Making the Hypotenuse Radius, the Leg AB will be the Sine Complement of the required Angle; therefore, As Hypotenuse to Radius, so Leg AB to the Complement of the Angle at A .

2. Making the Base Radius, the Hypotenuse is the Secant of the Angle at A ; therefore, As the Base of AB to Radius, so the Hypotenuse AC to the Secant of the Angle at A .

CASE V. Given the Hypotenuse and a Leg, to find the other Leg. Given AC and AB , required BC .

1. Making the Hypotenuse Radius, the required Leg BC is the Sine of the Angle at A ; therefore having found the Angle at A by Case the fourth, the Proportion is, As Radius to the Hypotenuse, so the Sine of the Angle at A to the Leg BC required.

2. Making the Base Radius, the required Leg BC is the Tangent of the Angle at A ; therefore having found the Angle at A , as before, the Proportion is, As Radius to the Base, so Tangent of the Angle at A to the Leg BC required.

These two Cases are jointly comprehended in the fourth and fifth Cases of *Plain Sailing*, in each of which there is given the Hypotenuse and a Leg, to find the other Leg and the Angles.

Note, It is most usual, in most Cases in *Plain Sailing*, to work after the Method here delivered, making Hypotenuse Radius, because that way of stating brings it under that known Proportion of opposite Sides to opposite Angles.

CASE VI. *The Legs given, to find the Angles. Given*
 AB and BC , required BAC .

Note, When a Side is required, any Side may be made Radius; but to find an Angle a given Side may be made Radius; and here being obliged to find an Angle before we can find the Hypotenuse, we first make the Leg AB Radius, and then BC is the Tangent of the Angle at A . Therefore as AB to Radius so BC to the Tangent of the Angle at A required.

CASE VII. *Given the Legs, to find the Hypotenuse. Given AB and BC , to find AC .*

First find the Angle at A as before, and then,

1. Making the Hypotenuse Radius, the Base AB is the Sine Complement, and the Perpendicular BC the Sine of the Angle at A ; therefore, as Sine Complement of the Angle at A to the Base AB , so Radius to the Hypotenuse AC required. Or, as Sine of the Angle at A to the Leg BC , so Radius to the Hypotenuse required.

2. Making Base Radius, and having found the Angle at A , it is, As Radius to the Base, so the Sine of the Angle at A to the Hypotenuse.

These two Cases are both contained under the sixth Case of *Plain Sailing*; and if you carefully observe the Rules laid down in the Beginning of *Plain Sailing Geometrical*, about the Application of *Plain Triangles* to Questions in Navigation, the Connection between them will appear so plain, and the Directions given in one will be so plain and pertinent in the other, that there needs no more to be said to instruct the Reader as to the Solution of right-angled plain Triangles.

SECT. II.

Of Oblique Plain Triangles.

I shall be a little more particular in this Section of oblique Triangles, because we have them not answered numerically elsewhere in this Book, except in some Questions at the latter End.

CASE I. Two Angles and a Side opposite to one of them given, to find the Side opposite to the other.

Given $\left\{ \begin{array}{l} \text{The Angle at } A - 30^{\circ} 0' \\ \text{The Angle at } B - 45^{\circ} 0' \\ \text{The Side } BC - 290 \end{array} \right\}$ Required the Side AC .

By Axiom the Second.

As Sine of A	— 30	00	Co. Ar.	0.30103
To Side opposite BC	— 290	—		2.46239
So Sine of B	— 45	00		9.84948
To Side opposite AC required	410	—		2.61390

Note, Here being no Radius in this Proportion, I have taken the Complement Arithmetical of first Logarithm, and added all the three Sums together, omitting one to the Left Hand, according to the Directions in the Beginning hereof.

CASE II. Two Sides and an Angle opposite to one of them given, to find the Side opposite to the other.

Given $\left\{ \begin{array}{l} \text{The Side } AB - 560 \\ \text{The Side } AC - 410 \\ \text{The Angle } B - 35^{\circ} 0' \end{array} \right\}$ Required the Angle at C .

By

By Axiom the Second.

As Side AC ————— 410 *Co. Ar.* 7.38722
 To Sine of the Angle opposite 45° 0' ————— 9.84948
 So Side AB ————— 560 ————— 2.74818
 To Sine of the Angle opposite 74° 58' ————— 9.98488

Note, This Answer is ambiguous, and therefore it is necessary first to know whether the Angle sought be acute or obtuse, which if acute, it is 74° 58', but if obtuse, it is found by subtracting 74° 58' from 180, the Remainder 105° 2' is the obtuse Angle required.

CASE III. *Given two Sides, and an Angle opposite to one of them, to find the third Side.*

Given { The Side AB ————— 560 } Required the Side
 { The Side AC ————— 410 } BC .
 { The Angle at B 45° 0' }

Find the Angle at C , as in Case II. which, if supposed Acute, is 74° 58'; then the two Angles B and C being given, the third is found by Subtraction to be 60° 2'. Then by Axiom the second,

As Sine of B ————— 45° 0' ————— *Co. Ar.* 0.15051
 To Side opposite AC ————— 410 ————— 2.61278
 So Sine of A ————— 60° 2' ————— 9.93767
 To Side opposite ————— 502 ————— 2.70097

But if the Angle at C had been supposed obtuse, viz: 105° 2', the Angle at A would have been 29° 58', and then the Operation is,

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As Sine of B —————	$45^{\circ} 0'$	Co. Ar. 0.15052
To Side opposite AC ———	410 ———	2.61278
So Sine of A —————	$29^{\circ} 58'$	9.69853
To Side opposite —————	290 ———	2.46183

CASE IV. *Given two Sides and a contained Angle, to find either of the other Angles.*

Given	{	The Side AC ———	410	} Required the An-	
		The Side AB ———	560		gles B and C .
		The Angle A ———	$30^{\circ} 0'$		

By Axiom the Third.

As Sum of the given Sides —	970	Co. Ar. 7.01322
To their Difference ———	150 ———	2.17609
So Tang. of $\frac{1}{2}$ Sum of unknown		
Angles —————		$75^{\circ} 00' - 10.57194$
To Tang. of $\frac{1}{2}$ their Difference —	29 59	9.76126

The Sum is the greater Angle C — $104^{\circ} 59'$

The Difference is the lesser Angle B $45^{\circ} 1'$

CASE V. *Two Sides and a contained Angle given, to find the third Side.*

Given	{	The Side AC ———	410	}	Required the Side BC .
		The Side AB ———	560		
		The Angle A ———	$30^{\circ} 0'$		

Find the Angle B by Case IV. viz. $45^{\circ} 1'$. Then

As Sine of B —————	$45^{\circ} 1'$	Co. Ar. 0.15039
To Side opposite AC ———	410 ———	2.61278
So Sine of A —————	$30^{\circ} 0'$	9.69897
To Side opposite BC ———	290 ———	2.46214

CASE

CASE VI. *Three Sides given, to find an Angle.*

Given $\left\{ \begin{array}{l} \text{The Side } AC \ 410 \\ \text{The Side } CB \ 290 \\ \text{The Side } AB \ 560 \end{array} \right\}$ Required the Angle at A .

Let fall a Perpendicular from C the greatest Angle upon AB the greatest Side, by Axiom the fourth.

As the Base AB ————— 560 — 7.2518
 To the Sum of the Sides AC 410 } — 7.00 — 2.8450
 and CB 290 ————— }
 So the Difference of the said Sides — 120 — 2.0791

To the Difference of the Seg- } — 150 — 2.1760
 ments of the Base AD ————— }

The half Difference 75 added to half the Base 280 the Sum 355 is the Base AE .

The half Difference 75 subtracted from half the Base 280, the Diff. 205 is the Base EB .

Then in the right-angled Triangle AEC is given AE 355, AC 410, to find the Angle A .

As AC ————— 410 — 2.6127
 To Radius ————— 90° 0' 10.0000
 So AE ————— 355 — 2.5502

To Sine Comp. of the Angle at A 30 — 9.9174

After the same manner you may find the Angle E .

Main **SECT III.**

Parallel Sailing Trigonometrical.

Although the Method here proposed be new and short, without the Trouble of Logarithms, Sines, Tangents and Secants; yet I shall by the way set down an Example or two in every Case, both in *Plain Sailing* and *Mercator*, according to the old and common Method, partly for the help of those, who either through Negligence, or want of Opportunity to practise, have forgot at Sea what they learn'd at school; but chiefly, that in all the Examples wrought by the new Way, I may refer to those wrought by the old Way; that so the Reader seeing the exact Harmony and Concord which is between them, may to his great Satisfaction be convinced of the Verity and Infallibility of this new Method, equal to the best for Truth and Certainty, and superiour to all for Expedition and Readiness.

Plain Sailing.

CASE I. *Course and Distance given, to find Difference of Latitude and Departure.*

A Ship sails N.W. by N. 123 Miles, I demand Difference of Latitude and Departure.

First for the Difference of Latitude.

As Radius	— 90 00	— 10.06000
To the Distance sailed	— 123	— 2.08990
So Sine Compl. of the Course	— 56 15	— 9.91985
To Difference of Latitude	— 102 1	— 12.00975
		<i>For</i>

For the Departure.

As Radius	— — — — —	90 00	Co. Ar.	10.0000
To Distance sailed	— — — — —	123		2.089
So Sine of the Course	— — — — —	33 45		9.744
To Departure	— — — — —	68		11.834

Example 2. A Ship sails South 25 Degrees East
ly 96 Miles; I demand Difference of Latitude and
Departure.

For Difference of Latitude.

As Radius	— — — — —	90 00		10.0000
To Distance sailed	— — — — —	96		1.982
So Sine Comp. of Course	— — — — —	65 00		9.957
To Diff. of Latitude	— — — — —	87		11.939

For the Departure.

As Radius	— — — — —	90 00		10.0000
To Distance sailed	— — — — —	96		1.982
So Sine of the Course	— — — — —	25 00		9.621
To Departure	— — — — —	40 $\frac{1}{2}$		11.608

CASE II. *Course and Diff. of Latitude given, to find
Distance and Departure.*

A Ship sails S.W. by S. till her Diff. of Latitude
174 Miles; I demand her Distance and Departure.

For the Distance.

As Sine Comp. of Course	— — — — —	56 15		9.919
To Diff. of Latitude	— — — — —	174		2.240
So Radius	— — — — —	90 00		10.0000
To the Distance	— — — — —	209		2.320

For the Departure.

	°	'	Co. Ar.
As Sine Comp. of Course	56	15	0.08015
To Diff. of Latitude		174	2.24055
So Sine of Course	33	45	9.74474
To Departure		116	2.06544

Example 2. A Ship sails North 38 Degrees Wester-
till she raise the Pole 2 Degrees; I demand how
far she hath sail'd, and how much she is departed from
her first Meridian.

The 2 Degrees of Latitude reduced into Miles, is
20 Miles. Then for the Distance.

	°	'	
As Sine Comp. of Course	38	00	9.89653
To Diff. of Latitude		120	9.07018
So Radius		90	10.00000
To the Distance		152	2.18265

For the Departure.

	°	'	Co. Ar.
As Sine Comp. of Course	52	00	0.10347
To Diff. of Latitude		120	2.07918
So Sine of Course	38	00	9.78934
To Departure		94	1.97199

ASE III. Course and Departure given, to find Di-
stance and Difference of Latitude.

A Ship sails S E. by S. till her Departure be 103
Miles; I demand her Distance and Difference of La-
titude.

For

For the Distance.

As Sine of the Course	— 33 45 —	9.7447
To Departure	— 103 —	2.012
So Radius	— 90 00 —	10.0000
To the Distance	— 185 —	2.268

For the Difference of Latitude.

As Sine of the Course	— 33 45 —	0.259
To Departure	— 103 —	2.012
So Sine Comp. of Course	— 56 15 —	9.919
To Diff. of Latitude	— 154 1 —	2.187

Example. 2. A Ship sails North 19 Deg. 41 Min. Easterly, which is N.N.E. & Northerly, till her Departure be 72 Miles; her Distance and Difference Latitude is required.

For the Distance.

As Sine of the Course	— 19 41 —	9.527
To Departure	— 72 —	1.857
So Radius	— 90 00 —	10.000
To the Distance	— 214 —	2.229

For the Difference of Latitude.

As Sine of Course	— 19 41 —	0.47
To Departure	— 72 —	1.857
So Sine Comp. of Course	— 70 19 —	9.973
To Difference of Latitude	— 201 —	2.201

CASE IV. Distance and Difference of Latitude given,
to find Course and Departure.

A Ship sails between the North and East 110 Miles,
and then finds by Observation that she hath raised the
pole one Degree: I demand the Course and Departure.

The Difference of Latitude reduced to Miles or
minutes, is 60.

Then for the Course.

As the Distance	110	2.04139
To Radius	90° 00'	10.00000
So Difference of Latitude	60	1.77815
To Sine Comp. of Course	56 57	9.73676

Which is N.E. by E. nearest, or N. E. by E. 42 min.
sterly.

For the Departure.

As Radius	90° 00'	10.00000
To the Distance	110	2.04139
So Sine of Course	56 57	9.92334
To Departure	92	1.96473

Example the Second.

A Ship sails between the North and East, till her
Difference of Latitude be 103 Miles, and then is di-
stant from the Place she sail'd from 117 Miles; her
Course and Departure is requir'd.

For the Course.

As the Distance	117	2.66818
To Radius	90° 00'	10.00000
So Difference of Latitude	103	2.01284
To Sine Comp. of Course	28 19	9.94466

F

For

For the Departure.

As Radius	—	—	90° 00'	—	10.000
To the Distance	—	—	117	—	2.068
So Sine of the Course	—	28	19	—	9.676
To Departure	—	—	55 $\frac{1}{2}$	—	11.744

The Course is N.N.E. somewhat more than half Point Easterly, and the Departure 55 $\frac{1}{2}$ Miles.

CASE V. *Distance and Departure given, to find the Course and Difference of Latitude.*

A Ship sails between the South and West 124 Miles her Departure 95 Miles, I demand the Course, and Diff. of Latitude.

For the Course.

As the Distance	—	—	124	—	2.092
To Radius	—	—	90° 00'	—	10.000
So Departure	—	—	95	—	1.977
To Sine of the Course	—	50	00	—	9.880

For Difference of Latitude.

As Radius	—	—	90° 00'	—	10.000
To the Distance	—	—	124	—	2.092
So Sine Comp. Course	—	40	00	—	9.808
To Difference of Latitude	—	80	—	—	11.901

The Course is S. W. $\frac{1}{2}$ Point, Westerly, or 4 Points nearest: The Difference of Latitude 80 Miles.

Example the Second.

A Ship sails North Easterly 100 Miles, till her Departure be 38 Miles, her Course and Difference of Latitude is required.

For the Course.

As the Distance	— 100 —	2.00000
To Radius	— 90° 00' —	10.00000
So the Departure	— 38 —	1.57978
To Sine of the Course	— 22 20 —	9.57978

For Difference of Latitude.

As Radius	— 90° 00' —	10.00000
To the Distance	— 100 —	2.00000
So Sine Comp. Course	— 67 40 —	9.96613
To Difference of Latitude	— 92 ½ —	1.96613

The Course N. N. E. *ferè*; and Difference of Latitude 92 ½.

ASE VI. *Difference of Latitude and Departure given, to find Course and Distance.*

A Ship sails between the North and West, till her Difference of Latitude be 220 Min. and Departure 108 Min. or Miles. I demand Course and Distance.

For the Course.

As Difference of Latitude	— 220 —	2.34242
To Radius	— 90° 00' —	10.00000
So Departure	— 108 —	2.03342
To Tangent of the Course	— 26 09 —	9.69100

For the Distance.

As Sine of the Course	— 26° 9' —	9.644
To Departure	— 108 —	2.011
So Radius	— 90° 0' —	10.000
To the Distance	— 245 —	2.389

The Course N.N.W. somewhat more than $\frac{1}{4}$ West, the Distance 245 Miles.

Example the Second.

A Ship sails between the South and West, until the Difference of Latitude be 309 Min. and Departure 206 Min. I demand the Course and Distance.

For the Course.

As Diff. of Latitude	— 309 —	2.489
To Radius	— 90° 00' —	10.000
So Departure	— 206 —	2.311
To Tangent of the Course	— 33° 41' —	9.821

For the Distance.

As Sine of the Course	— 33° 41' —	9.741
To Departure	— 206 —	2.411
So Radius	— 90° 00' —	10.000
To the Distance	— 371 —	2.561

The Course S.W. by S. *ferè*, the Distance 371 Miles.

Thus I have set down two Examples, in every Case of Plain Sailing, according to the old and common Way of working by Logarithms, Sines, and Tangents.

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ents, having observed in the three first Cases where the Course is given, to set one Question with the Course given in Points of the Compass, as N.N.W. &c. and another with the Course given in Degrees, South 25 Degrees, Easterly, &c. intending in the sequel hereof, to proceed to shew the Reader how to answer all the same Questions, (where the Course is either given or requir'd, in Points, Half-points, or quarter-points of the Compass) without any Canon, Scale or Compasses, only by two Tables, each of which, (or both if Need required) might be contain'd on one Page hereof, which Tables you have at the beginning of the second Part of this Book; by which Tables only you may work all the Cases in Plain Sailing; and keep a Journal by that Way, without a Traverse Table, or the voluminous Tables of Logarithms, Sines, Tangents, &c. which fill up the far greater part of some of our Epitomes of Navigation now in print; You may also by the same, and a Table of Meridional Parts, work all the Cases in Mercator, and keep a Reckoning throughout the World; and not on- ly so, but that the Work may justly deserve the Title of a new Method, I shall add some Rules teaching how to work any Question in plain Trigonometry, or Navigation; only by the Pen, or a Piece of Chalk, without any Geometrical Projection, by Scale and Compasses; or Arithmetical Calculation by Sines and Tangents; so that if at Sea you have lost all Books and Instruments, or if a-shore you be in Company where you have no Books, nor Instruments present, you shall work any Question as easily as a Question of Common Arithmerick, a Thing never yet known, or publish'd by any: But I shall now proceed to propose an Example, or two, in the several Cases of,

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SECT. IV.

Mercator's Sailing Trigonometrical.

CASE I.

One Latitude, Course and Distance, given, to find the other Latitude, and Difference of Longitude.

IN this, and the other Cases, we shall have Occasion to make use of the Meridional Difference of Latitude, for the finding of which, observe; two Places (whose Meridional Difference of Latitude you seek) be both in North Latitude, or both in South Latitude, subtract the meridional Parts of the lesser Latitude from the Meridional Parts of the greater Latitude, the Remainder is the Meridional Difference of Latitude; but if one be in North Latitude, and the other in South, add the Meridional Parts of both Latitudes together, the Sum is the Meridional Difference of Latitude; the following Examples will make it plain.

A Ship in Latitude of $50^{\circ} 00'$. North, sails North by N. 987 Miles; I demand the Latitude come to, as also the Difference of Longitude.

As radius	_____	$90^{\circ} 00'$	_____	10.000
To the Distance	_____	987	_____	2.994
So Sine Comp. Course	_____	$56^{\circ} 15'$	_____	9.915
To proper Diff. of Latitude	_____	820	_____	12.912

The Difference of Latitude 820 min. divided by 60, to bring it into Degrees, is $13^{\circ} 40'$, which added to 50° deg. (because the Ship sails towards the Pole)

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nd increases her Latitude) the Sum $63^{\circ} 40'$ is the
atitude come to. Then to find the Meridional Diffe-
ence of Latitude between Lat. $63^{\circ} 40'$ and Lat. 50° .

Meridional Parts for Lat. $63^{\circ} 40'$	—	—	—	4994
Meridional Parts for Lat. $50^{\circ} 00'$	—	—	—	3475
Subtr. one from t'other, rests Merid. Diff. Lat.				1519

Then for Difference of Longitude.

As Radius	—	—	$90^{\circ} 00'$	—	10.00000
To Merid. Diff. Lat.	—	—	1522	—	3.18241
So Tangent of the Course	—	—	33 45	—	9.82489
To Difference of Longitude	—	—	1017	—	12.00730

The Latit. come to is $63^{\circ} 41'$ and Diff. Long. 1017',
hich divided by 60 is $16^{\circ} 57'$ West Longitude, be-
use the Course is Westerly.

ASE II. *Both Latitudes and Course given, to find
the Distance and Difference of Longitude.*

A Ship sails from St. Abb's Head, in Lat. $56^{\circ} 25' N$.
d sails away N. N. E. several Days, and then finds
rself by Observation to be in Latitude $68^{\circ} 30'$; I de-
nd how far she hath sail'd, and what is her Diffe-
nce of Longitude?

Meridional Parts for	—	—	$68^{\circ} 30'$	—	5712
Meridional Parts for	—	—	$56^{\circ} 25'$	—	4119
Meridional Difference of Latit.	—	—	—	—	1593
Proper Difference of Latitude	—	—	12 05, or	—	725

Then for the Distance.

As Sine Comp. Course, sc.	—	—	$22^{\circ} 30'$	—	9.96561
To proper Diff. of Latitude	—	—	725	—	2.86033
So Radius	—	—	$90^{\circ} 00'$	—	10.00000
To the Distance	—	—	785	—	2.89472

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For Difference of Longitude.

As Radius	— 90° 00' —	10.0000
To Merid. Diff. Latitude	— 1594 —	3.2012
So Tangent of the Course	— 22° 30' —	9.6172
To Diff. of Longitude	— 660 —	12.8194

The Distance is 785 Miles, or 262 Leagues almost and the Difference of Longitude is 660 Min. or 11 Degrees East from *St. Abb's Head*, which, added to 14° 12' the Longitude of *St. Abb's Head*, (accounting from *Pico Teneriff*) the Sum 25° 12' is the Longitude the Ship is in, which being found, find in a Mercator's Chart the Longitude so found, and the Latitude by Observation 68° 30' and that is the Point in the Chart that your Ship is in.

CASE III. One Latitude, Course, and Difference of Longitude given, to find the other Latitude and Distance.

A Ship in Latitude 50, sails N.N.W. till her Difference of Longitude be 7 Degrees, or 420 Min. Demand the other Latitude and Distance.

For the other Latitude.

As Tangent of the Course	— 22° 30' —	9.6172
To Difference of Longitude	— 420 —	2.6114
So Radius	— 90° 00' —	10.0000
To Meridional Diff. Lat.	— 1014 —	3.0060
Merid. Parts answering to Lat. 50° 00'	— — —	14.0000
To which add Meridional Diff. of Lat.	— — —	10.0000
The Sum	— — —	4.0060

Which found in the Table of Meridional Parts answers to 59° 40' the Latitude come to.

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Then for the Distance.

As Sine Comp. of Course — $67^{\circ} 30'$ — 9.96561
 To proper Diff. of Lat. — — — 580 — 2.76343
 So Radius — — — $90^{\circ} 00'$ — 10.00000
 To the Distance — — — 628 — 2.79782

The Latitude come into is $59^{\circ} 40'$. the Distance 628 Miles.

ASE. IV. Both Latitudes and Distance given, to find the Course and Difference of Longitude.

A Ship in Latitude $50^{\circ} 00'$ W. sails 3505 Miles, and then is found by Observation to be in Latitude 12° N. I demand her Course, and Difference of Longitude.

The proper Difference of Latitude is found by Subtracting the lesser Latitude from the greater, the Remainder is the Difference of Latitude in Degrees and Minutes, which multiplied by 60, gives the Difference of Latitude in Miles.

Example.

Greater Latitude $50^{\circ} 00'$ } 36 48
 Lesser Latitude — $12^{\circ} 12'$ } 60
 Remains — — — 36 48 } 2208 proper Diff. Lat.

Meridional Parts for Lat. — $50^{\circ} 00'$ — 3475
 Meridional Parts for Lat. — $12^{\circ} 12'$ — 799
 Meridional Difference of Latitude — — — 2676
 Proper Difference of Latitude — — — 2208

For the Course.

As Distance — — — 3505 — 3.54469
 To Radius — — — $90^{\circ} 00'$ — 10.00000
 So proper Diff. of Lat. — 2208 — 3.34400
 To Sine Comp. Course — $50^{\circ} 57'$ — 9.79931
 Far

For the Difference of Latitude.

As Radius	— — —	90° 00'	— 10.0000
To Meridional Diff. of Lat.	2676	—	3.427
So Tang. of the Course	— 50 57	—	10.096
To Difference of Longitude	3298	—	3.518

In the four foregoing Cases I have purposely omitted the Canons for finding the Departure, it being sufficiently taught in the Cases of Plain Sailing; and the Canons for finding it are exactly the same in both, according to what is given. Nevertheless, in all the following Cases (except the 6th) the Departure is given, and therefore I shall make it one necessary Term in each of the ensuing Cases: And when we come to the Practical Part, viz. the Keeping of a Journal, I shall lay down some easy and compendious Ways for reducing Departure to Difference of Longitude both by Mercator and middle Latitude, without any Canon.

CASE V. *Both Latitudes and Departure given, to find Course, Distance, and Diff. of Longitude.*

A Ship sails from Lat. $55^{\circ} 00' N.$ and sails between the North and East into Lat. $56^{\circ} 10' N.$ her Departure 50 Min. or Miles; I demand the Course made, the Distance sail'd, and the Difference of Longitude.

For the Course.

As proper Diff. of Lat.	— — —	70	— 1.8450
To Radius	— — —	90 00	— 10.0000
So Departure	— — —	50	— 1.6989
To Tangent of the Course	35 32	—	9.8538

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For the Distance.

As Sine of the Course	— 35° 32' —	19.76430
To Departure	— — — 50	1.69897
So Radius	— — — 90 00 00	10.00000
To the Distance	— — — 86	11.91467

For Difference of Longitude.

As Radius	— — — 90 00	10.00000
To Meridional Diff. of Lat.	— 124 —	2.09342
So Tang. of the Course	— 35 32 —	9.85388
To Diff. Longitude	— — — 89 fere	11.94730

Or, which is the same.

As Proper Diff. of Lat.	— 70 Co. Ar.	3.15499
To Merid. Diff. Lat.	— 124 —	2.09342
So Departure	— — — 50	1.69897
To Difference of Longitude	89 fere	11.94738

ASE VI. *Both Latitudes, and Difference of Longitude given, to find Course, Distance and Departure.*

Suppose two Places, one in Latitude 56 deg. 15 m. the other in Lat. 58 deg. 15 m. N. their Difference of Longitude 2 deg. 30 min. I demand the Course and Distance from the Southermost to the Northermost, and also the Departure.

Proper Diff. Lat.	— — — 140
Meridional Diff. Lat.	— — — 260

For

For the Course.

As Merid. Diff. Lat.	— 11 — 260	— 30 —	2.416
To Radius	— — — 90° 00	— 10.000	
So Diff. Long.	— — — 150	— 2.176	
To Tang. Course	— — — 29 55	— 9.759	

For the Distance.

As Sine Comp. Course	— 29 55	— 9.918	
To proper Diff. Lat.	— 11 — 260	— 2.146	
So Radius	— — — 90° 00	— 10.000	
To the Distance	— — — 161	— 2.108	

For the Departure.

As Sine Comp. Course	sc. 29 55	Co. Ar. 0.0619	
To proper Diff. Lat.	— — — 140	— 2.146	
So Sine Course	— — — 29 55	— 9.697	
To Departure	— — — 80	— 1.905	

Or, as Radius to proper Difference of Latitude,
Tangent of the Course to Departure.

CASE VII. One Latitude, Course and Departure
given, to find the other Latitude, Distance, and Difference
of Longitude.

A Ship in Latitude $58^{\circ} 00'$ N. sails S. S. W. $\frac{1}{2}$ W.
till her Departure be 60 Min. I demand the Latitude
come to, Distance sail'd, and Difference of Longitude.

☞ If your Difference of Longitude be East, add
it to, or if West, subtract it from, the Longitude sail'd
from, and the Sum or Remainder is the Longitude come
into, if you begin to reckon your Longitude from Paris.

Ten

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meriff, (which I hold the best Way) but if you begin
 ur Longitude at the Place sail'd from, (according
 Mariners Compass rectified) you only reckon your
 Longitude East or West, according to the Denomi-
 tion of your Departure, whether East or West.

For the Difference of Latitude.

As Sine of the Course ——— 28 07 *Co. Ar.* 0.32672
 To Departure ——— 60 ——— 1.77815
 So Sine Comp. of Course ——— 61 53 ——— 9.94546
 To Diff. of Latitude ——— 112 ——— 12.05034
 Difference of Latitude 112 Miles, or Minutes; or,
 deg. 52 min. which, subtracted from the Latitude
 Id from, 58 deg. (because the Course is southerly)
 e Remainder, 56° 8'. is the Latitude come to.

Then for the Distance.

As Sine of the Course ——— 28 07 ——— 9.67326
 To Departure ——— 60 ——— 1.77815
 So Radius ——— 90 00 ——— 10.00000
 To the Distance ——— 127 ——— 2.10489

For Difference of Longitude.

As Radius ——— 90 00 ——— 10.00000
 To Meridional Diff. of Lat ——— 206 ——— 2.31386
 So Tangent of the Course ——— 28 07 ——— 9.72780
 To Difference of Longitude ——— 110 ——— 12.04166

Or Difference of Longitude may be thus found.

As proper Diff. Lat. ——— 112 *Co. Ar.* 7.94968
 To Meridional Diff. Lat. ——— 206 ——— 2.31386
 So Departure ——— 60 ——— 1.77815
 To Difference of Longitude ——— 110 ——— 12.04166

CASE

CASE VIII. *One Latitude, Distance and Departure given, to find the other Latitude, Course, and Difference of Longitude.*

A Ship in Lat. 58 deg. N. sails between the South and West 127 Miles, and then finds her Departure to be 1 Degree, or 60 Minutes, I demand as above.

For the Course.

As Distance	127	
To Radius	90 00	10.0000
So Departure	60	1.7781
To Sine of the Course	28 11	9.6741

For the Difference of Latitude.

As Sine of the Course	28 11	0.4756
To Departure	60	1.7781
So Sine Comp. of Course	61 49	9.9451
To Difference of Latitude	112	12.0481

For the Difference of Longitude.

As Radius	90 00	10.0000
To Merid. Diff. of Lat.	206	2.3111
So Tang. of the Course	28 11	9.7290
To Difference of Longitude	110	12.0421

The Difference of Latitude is 112 Minutes, or Degree 52 Minutes, which subtracted from the Latitude sail'd from, 58 Deg. the Remainder, 56 Deg. 8 min. is the Latitude come to; and the Difference of Longitude is 110 Min. or 1 Deg. 50 Min. which is to be subtracted from the Longitude sail'd from, you account from *Pico Teneriff, &c.*

How to work Mercator's Sailing, without a Table of Meridional Parts.

The Table of Meridional Parts may be supplied by the Table of Artificial Tangents; for every half Degree of the Tangents above 45 answers to one Degree of Latitude, (the Characteristick or Index of the Tangent being rejected) and therefore to find the Meridional Leagues for any Latitude, add half the given Latitude to 45, the Sum is a Degree, whose Tangent multiplied by ten, and the Product divided by 376, the Quotient is the Meridional Leagues belonging to that Latitude, which multiplied by 3, gives (nearly) the Meridional Parts found in the Table.

Note, If you have a Table that hath 6 Figures, or more, in the Tangents, besides the Index, you may use the first 6 Figures, and need not multiply them by 10 as before.

But because this Way is not of Use, except when the Latitudes are given or found, to find the Difference of Longitude, 'tis best to find the Tangents answering to both Latitudes, and subtract the less from the greater, and divide the Remainder by 376, which gives the Meridional Difference of Lat. in Leagues, which if you please you may reduce to Miles, by multiplying by 3) without further Trouble.

Example.

In the foregoing Question in the eighth Case of Mercator's Sailing Trigonometrical the two Latitudes were found to be $58^{\circ} 0'$ and $36^{\circ} 8'$.

Half of $58^{\circ} 0'$ is $29^{\circ} 0'$

To which add $45^{\circ} 0'$

The Sum is $74^{\circ} 0'$ whose Tang. is 542508

Half

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Half of $56^{\circ} 8'$ is $28^{\circ} 4'$

To which add— $41^{\circ} 0'$

The Sum is— $73^{\circ} 4'$ whose Tang. is $\{16471$

Remains—26072

$176)26072(69$ Merid. Diff. Lat. in Leagues— 69

1472 Which multiplied by— 10

1472 Gives Merid. Diff. Lat. in Miles 207

Nearly agreeing with that found by the Table.

And altho' this be not exactly the same with the Table, yet the Difference is scarce discernable; therefore it may be of great use where Tables of *Fictional Parts* are wanting.

SECT. V.

Parallel Sailing Trigonometrical.

SOME rank the Cases of *Parallel Sailing* among the rest of the Cases of *Mercator's Sailing*; and indeed not without good Reason, seeing it is grounded upon the same Projection, and is really a Branch of the same. Nevertheless, seeing both *Data* and *Resolves* relate only to the Distance or Difference of Longitude, &c. of Ships or Places in the same Parallel Latitude; I chuse rather to speak of it in so many distinct Cases under that Head, and shall (as before) down an Example in every Case; and work it in a common Way (*viz.* by Logarithms, &c.) here, and shall afterwards proceed to work it also, as well in *Plain* and *Mercator's*, without any Canon, only in common Arithmetick.

CAS

CASE I. *Two Ships (or Places) in one Parallel, their Latitude and Distance given, to find their Difference of Longitude.*

Suppose two Ships in Latitude $50^{\circ} 00'$, distant 76 Miles; I demand their Difference of Longitude.

As Sine Comp. Latitude	— $50^{\circ} 00'$ —	9.80807
To Radius	— $90^{\circ} 00'$ —	10.00000
So Distance	— 76 —	1.88081
To Difference of Longitude	— 118 —	2.07274

The Difference of Longitude 118', or $1^{\circ} 58'$.

CASE II. *Two Places in one Parallel, their Latitude and Difference of Longitude given, to find their Distance.*

This is only the former Canon inverted, as in the following Example.

The Latitude of two Ships (or Places) and their Difference of Longitude given, to find their Distance.

Example. Suppose two Places in the Latitude of 50° , their Difference of Longitude 118'; I demand their Distance.

The Difference of Longitude is 118 Min.

As Radius	— $90^{\circ} 00'$ —	10.00000
To Sine Comp. Lat. S.C.	— $40^{\circ} 00'$ —	9.80806
So Diff. Longitude	— 118 —	2.07188
To the Distance	— 76 —	1.87994

CASE III. *Two Places, in one Latitude, their Distance and Difference of Longitude given, to find the Latitude they are in.*

Example. A Ship sails due West 2700 Miles, then finds her Difference of Longitude to be 4200 Min. I demand what Latitude the Ship sails in.

As Diff. Longitude	—	—	4200	—	3.621
To Radius	—	—	90° 00'	—	10.000
So is the Distance	—	—	2700	—	3.411
To Sine Comp. Lat. S. C.	—	—	50 00	—	9.800

CASE IV. *Two Ships sailing directly North or South, their Distance in one Parallel given, to find their Distance in another Parallel.*

Example. Suppose two Ships in Latitude 50 Deg. 00 Min. North, distant 200 Miles, sail both directly North into Latitude 73 Deg. 00 Min. I demand their Distance in that Parallel.

As Sine Comp. of Lat. sail'd from	50 00	Co. Ar.	0.19
To their Distance in that Parallel	200	—	2.30
So Sine Comp. of Lat. sail'd to	73 00	—	9.46
To their Distance in Lat. sail'd to	91	—	11.95

CASE V. *Two Ships in one Parallel, with their Distance in that Parallel given, sailing both directly North or South, with their Distance in the Parallel sail'd given, to find the Latitude come to.*

Example. Two Ships in Latitude 50 Deg. 00 Min. distant 200 Miles, sail both directly North, till their Distance is but 91 Miles; I demand the Latitude come to.

Sect. 5. *Parallel Sailing Trigonometrical.*

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This is but the last Canon inverted, viz.

Co. Ar.

As their Distance in Lat. sail'd from — 200 — 7.69897
 To Sine Comp. of Lat. sail'd } — 50° 00' — 9.80807
 from S. C. ————— }
 So Distance in Lat. come to ————— 91 — 1.95904
 To Sine Comp. of Lat. come to ————— 73 00 — 19.46608

In these Five Cases of *Parallel Sailing* I have set down
 at one Example in each Case, it being of no great
 use in the Practice of Navigation; and yet it was
 not fit it should be omitted, because of its Usefulness,
 being a good Help towards a right Notion and
 apprehension of the Terrestrial Globe; for in *Plain*
Sailing there is no such Thing as Difference of Longi-
 tude, as distinct from Departure; but here the Diffe-
 rence between the one and the other is plainly evi-
 dent, the Difference of Longitude being sometimes
 twice or thrice as much as the Departure, it bearing
 always the same Proportion to the Departure, as Ra-
 dius doth to Sine Complement of the Latitude or Pa-
 rallel sail'd in.

SECT. VI.

Middle Latitude Sailing Trigonometrical.

Altho' *Middle Latitude Sailing* is not exactly true,
 yet because of its (general) Conformity to the
 Globe, I shall not altogether omit it; for notwith-
 standing that it comes short of *Mercator's* (or rather
Wright's) *Sailing* (in which the Degrees of Longi-
 tude bear exactly the same Proportion to the Degrees

of Latitude in any Parallel, as it doth upon the Globe) yet it exceeds *Plain Sailing* (which supposeth the Earth to be a plain Superficies, and the Degrees of Longitude and Latitude to be every where equal and therefore seeing it hath been sometimes taught and practised, as one of the Kinds of Sailing (or keeping a Reckoning) now in Use; I shall proceed to an Example in each Case thereof. And the rather I take notice of it, because when I come to go over this in the new Way of Working without any Canon I shall shew how it may be done, not only with more Ease and Expedition, but also much more nearly (not exactly) agreeing with *Mercator*, and consequently with the Globe it self, than what hath been commonly taught and practised in that Kind of Sailing, but shall refer that to its proper Place in the Second Part hereof, and shall here proceed (as in *Plain Sailing* and *Mercator, &c.*) to work the several Cases of *Middle Latitude Sailing* the common Way, and the Analogies or Proportions made use of herein (besides those taught in *Plain Sailing*, which are applicable and useful here as well as in *Mercator's Sailing*) are common to these two, *viz.*

As Difference of Latitude
To Difference of Longitude,
So Sine Complement of Middle Latitude
To Tangent of the Course from the Meridian.

The other Proportion is,

As Sine Complement of Middle Latitude
To Radius,
So is the Departure
To the Difference of Longitude.

And these Proportions may be inverted according to what is given and what is required by *Euclid*,

Prop. 14 & 16. & Corol. always observing to make the required Term the last of the four in the Proportion: As suppose both Latitudes and Course be given, and Difference of Longitude required; then the Proportion will be,

As Sine Complement of Middle Latitude
To Tangent of the Course,
So Difference of Latitude
To Difference of Longitude.

And so in others, as in the ensuing Operations will more plainly appear.

There is also another Proportion, of Use for finding the Course, Distance or Difference of Longitude, when any two of them, together with both Latitudes, are given or found; and the Proportion is,

As Sine Complement of Middle Latitude
Is to the Sine of the Course from the Meridian,
So is the Distance sailed
To the Difference of Longitude.

And so by inverting the Canon, any three of them being given, the fourth may be found.

CASE I. One Latitude, Course and Distance given, to find the other Latitude, Departure, and Difference of Longitude.

A Ship in Latitude 50 Deg. 00 Min. North, sails W. by N. 987 Miles; I demand the Latitude come to, with the Departure and Difference of Longitude.

See the same Question in *Mercator's Sailing*, Case the First.

For the Difference of Latitude.

As Radius	— — — — —	90 00	— — — — —	10.00000
To the Distance	— — — — —	987	— — — — —	2.99412
So Sine Comp. of Course	— — — — —	56 15	— — — — —	9.91984
To Diff. of Latitude	— — — — —	821	— — — — —	2.91416
The Latitude come to is 63 Deg. 41 Min.				

For the Departure.

As Radius	— — — — —	90 00	— — — — —	10.00000
To the Distance	— — — — —	987	— — — — —	2.99412
So Sine of the Course	— — — — —	33 45	— — — — —	9.74472
To the Departure	— — — — —	548	— — — — —	2.73999

For the Difference of Longitude.

Because this Canon for finding the Difference of Longitude is grounded upon the Middle Latitude, observe that it is always found by adding the 2 Latitudes together, and half the Sum is the Middle Latitude required.

Thus in this Example the Latitude sail'd from	— — — — —	50 00
The Latitude sail'd to is	— — — — —	63 41
The Sum is	— — — — —	113 41
The half of which is the Middle Lat. viz.	— — — — —	56 50 1/2

The exact Half is $56^{\circ} 50' \frac{1}{2}$; but you need not be careful to half a Minute: But where the Sum is an odd Minute, take always the bigger Half; for the Middle Latitude is a Latitude rather too little to work with, and consequently the Sine Complement of it is always a Sine rather too great, and makes the Longitude come out less than really it should be: And altho' there is no Way to find a Mean Latitude to work with

As Middle Latitude (without too much Trouble)
it will bring out the required Longitude the same
nearly with *Mercator*; yet the Middle Latitude found
before being always too little, the taking the greater
half, where an odd Minute happens, will be so far
in augmenting the Error, that it rather lessens it,
makes the Longitude so found more nearly, (tho'
exactly) conformable to the Longitude found by
Mercator's Sailing; which for Instance in this first
question we shall work by each of the three Canons
prementioned.

	o	i	Co. Ar.
As Sine Comp. of Middle Lat.—	56	51	— 0.26215
To Tang. of the Course ———	33	45	— 9.82489
To Diff. of Lat. ———	821		— 2.91434
To Diff. of Longitude ———	1003		— 23.00138

	o	i	
As Sine Comp. of Middle Lat.—	56	51	— 9.73785
To Radius ———	90	00	— 10.00000
To Departure ———	548		— 2.73878
To Diff. of Longitude ———	1003		— 3.00093

	c	i	Co. Ar.
As Sine Comp. of Middle Lat.—	56	51	— 0.26215
To Sine of the Course ———	33	45	— 9.74473
To is the Distance ———	987		— 2.99432
To Diff. of Longitude ———	1003		— 3.00120

SE II. Both Latitudes and the Course given, to find
Distance, Departure, and Difference of Longitude.

Ship takes her Departure from *St. Abb's Head*, in
Latitude 56 Deg. 25 Min. North, and sails N. N. E.
several Days, and then finds herself by Observa-
tion to be in Latitude 68 Deg. 30 Min. North; I de-
termine the Distance sailed, with her Departure and
Difference of Longitude.

See the same Question in *Mercator's Sailing*, Case the Second. The Difference of Latitude is 12 Deg. 5 Min. or 725 Min. or Miles.

Then for the Distance.

As Sine Comp. of Course S.C.	— 22 30 —	9.965
To Diff. of Latitude	— — —	725 — 2.869
So is Radius	— — —	90 00 — 10.000
To the Distance	— — —	785 — 2.894

Then for the Departure.

As Sine Comp. of Course S.C.	— 22 30 —	0.014
To Diff. of Latitude	— — —	725 — 2.869
So Sine of Course Sine	— — —	22 30 — 9.582
To Departure	— — —	300 — 2.477

The two Latitudes $\left\{ \begin{array}{l} 56^{\circ} 25' \\ 68 \quad 30 \end{array} \right.$

Sum — 124 55

$\frac{1}{2}$ Sum — 62 28 the Middle Latitude (required)

As Sine Comp. Mid. Lat. S.C.	— 62 28 —	9.664
To Radius	— — —	90 00 — 10.000
So Departure	— — —	300 — 2.477
To Difference of Longitude	— — —	649 — 2.812

CASE III. Both Latitudes and Distance given, to find the Course, Departure, and Difference of Longitude.

A Ship in Lat. 55 Deg. 00 Min. North, sails between the North and East 86 Miles, and is then come into Lat. 56 Deg. 10 Min. North; her Course, Departure, and Difference of Longitude is required.

Ex. 6.

Trigonometrical.

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See the same Question (only inverted, what is required there being given here) in *Mercator's Sailing*, case the fifth.

For the Course.

As Distance	86	1.93449
To Radius	90° 00'	10.00000
So Diff. of Lat.	70	1.84509
To Sine Comp of Course S.C.	35 31	9.91960

For the Departure.

As Radius	90 00	10.00000
To the Distance	86	1.93449
So Sine of the Course	35 31	9.76413
To Departure	50	1.69862

For the Difference of Longitude.

		<i>Co. Ar.</i>
As Sine Comp. of Mid. Lat.	55 35	0.24779
To Tang. of the Course	35 31	9.85086
So Diff. of Lat.	70	1.84509
To Diff. of Longitude	88	1.94374

Or,

As Sine Comp. of Mid. Lat.	55 35	9.75220
To Radius	90 00	10.00000
So Departure	50	1.69897
To Diff. of Longitude	88	1.94677

ASE IV. *Both Latitudes and Departure given, to find Course, Distance, and Difference of Longitude.*

A Ship in Latitude 55 Deg. 00 Min. North, sails between the North and East into Latitude 56 Deg. 00 Min. North, her Departure 50 Min. the Course, Distance, and Difference of Longitude is required.

See

See the same Question in *Mercator's Sailing*, Case the fifth.

For the Course by Case the sixth of Plain Sailing.

As Diff. of Latitude	70	1.8450
To Radius	90° 00'	10.0000
So Departure	50	1.6989
To Tang. of Course	35 32	9.8528

For the Distance.

As Sine of the Course	35 32	9.7643
To Departure	50	1.6989
So Radius	90 00	10.0000
To the Distance	86	1.9346

For Difference of Longitude.

As Sine Comp. of Mid. Lat.	55 35	9.7522
To Radius	90 00	10.0000
So Departure	50	1.6989
To Difference of Longitude	88	1.9467

CASE V. Both Latitudes and Difference of Longitude given, to find Course, Distance and Departure.

I demand the Course Distance and Meridian Distance between two Places, one in Latitude 56 Deg. 15 Min. North, the other in Latitude 58 Deg. 35 Min. North, their Difference of Longitude 2 Deg. 30 Min. See *Mercator*, Case the sixth.

For the Course.

Diff. of Latitude	140	Co. Ar.	7.85187
Diff. of Longitude	150		2.17609
Sine Comp. of Mid. Lat. $57^{\circ} 25'$			9.73120
Tang. of the Course	29 59		19.76116

For the Distance.

Sine Comp. of Course	60 01		9.93760
Diff. of Latitude	140		2.14612
Radius	90.00		10.00000
the Distance	162		2.20852

For the Departure.

Sine Comp. of Course S.C.	29 59	Co. Ar.	0.06239
Diff. of Latitude	140		2.14612
Sine of the Course	29 59		9.69875
Departure	81		11.90726

These Five are the most necessary and useful Cases of *Middle Latitude*, and indeed all that are of Use in finding a Reckoning; yet there are several other Cases which I shall insert for Variety; but because they are not so necessary in Practice, I shall only set down *Data* and *Quaestio*, with the Canons or Proportions finding what is required, and shall leave the Operations for the Reader's Practice.

SE VI. One Latitude, Course and Departure given, find the other Latitude, Distance, and Difference of Longitude.

A Ship in Latitude 55 Deg. 00 Min. North, sails North 35 Deg. 32 Min. Easterly, till her Departure is 10; I demand as above. For

For Difference of Latitude.

As Sine Course to Departure, so Sine Comp. Course to Diff. of Latitude.

The Difference of Latitude thus found, the Latitude come to is easily found, as in *Mercator*, Case the first, and both Latitudes being found, the Middle Latitude is found, as in *Middle Latitude Sailing*, Case the first. Then,

For the Distance.

As Sine of the Course to Departure, so Radius to the Distance.

For Difference of Longitude.

As Sine Comp. of Mid. Lat. to Radius, so Departure to Diff. of Longit.

CASE VII. One Latitude, Distance, and Departure given, to find the other Latitude, Course, and Difference of Longitude.

For the Course.

As Distance to Radius, so Departure to Sine of Course.

For Difference of Latitude.

As Radius to the Distance, so Sine Comp. of Course to the Diff. of Latitude.

For the Difference of Longitude.

As Sine Comp. of Middle Latitude to Radius, Departure to Difference of Longitude.

CASE VIII. Course, Departure, and Difference of Longitude given, to find both Latitudes and Distance.

For the Distance.

As Sine of the Course to Departure, so Radius to the Distance.

For the Distance.

As Sine of the Course to Departure, so Radius to Distance.

For Difference of Latitude.

As Sine of the Course to Departure, so Sine Comp. of the Course to Difference of Latitude.

For the Middle Latitude.

As Difference of Longitude to Departure, so Radius to Sine Comp. of Middle Latitude.

The Middle Latitude and Difference of Latitude found, both Latitudes are easily found; for adding the Difference of Latitude to the Middle Latitude, the Sum is the greater Latitude, and subtracting the said Half from the Middle Latitude, the Remainder is the lesser Latitude.

CASE IX. *Middle Latitude, Course and Distance given, to find both Latitudes, Departure, and Difference of Longitude.*

Difference of Latitude, and consequently both Latitudes.

As Radius to the Distance, so Sine Comp. of Course to Diff. of Latitude.

Then find both Latitudes, as in Case the eighth.

Then for Departure by Case the first of Plain Sailing.

As Radius to the Distance, so Sine of the Course to Departure.

For the Difference of Longitude.

As Sine Comp. of Middle Latitude to Sine of the Course, so is the Distance to the Difference of Longitude.

CASE X. *Course, Distance, and Difference of Longitude given, to find both Latitudes and Departure.*

For Middle Latitude.

As Difference of Longitude to the Distance, so is Sine of the Course to Sine Comp. of Middle Latitude.

For

For Difference of Latitude.

As Radius to the Distance, so Sine Comp. of Course to Diff. of Latitude.

Then find both Latitudes, as in Case the eighth.

For the Departure.

As Radius to the Distance, so Sine of the Course to Departure.

CASE XI. *Course, Difference of Latitude and Difference of Longitude given, to find both Latitudes, Distance and Departure.*

For the Middle Latitude.

As Difference of Longitude to Difference of Latitude, so is Tangent of the Course to Sine Comp. Middle Latitude.

By Difference of Latitude and Middle Latitude find both Latitudes, as in Case the Eighth.

For the Distance.

As Sine Comp. of the Course to Difference of Latitude, so is Radius to the Distance.

For the Departure.

As Sine Comp. of the Course to the Difference of Latitude, so Sine of the Course to Departure.

CASE XII. *Middle Latitude, Course, and Difference of Longitude given, to find both Latitudes, Distance and Departure.*

As Tangent of the Course to Sine Comp. of Middle Latitude, so Difference of Longitude to Difference of Latitude.

Then find Distance and Departure, as in Case the eleventh.

CASE XIII. *One Latitude, Departure, and Difference of Longitude given, to find the other Latitude, Course, and Distance.*

As Difference of Longitude to Departure, so Radius to Sine Comp. of Middle Latitude.

Subtract the given Latitude and Middle Latitude, less from the greater, the Remainder doubled is Difference of Latitude.

Then for the Course.

As Difference of Latitude to Radius, so Departure Tangent of the Course.

Then for the Distance.

As Sine of the Course to Departure, so Radius to Distance.

CHAP.

CHAP. III.

Navigation by Inspection.

SECT. I.

*How to work all the Cases in plain Sailing, and to
a Traverse; and also to keep a Reckoning both in La-
tude and Latitude, only by Inspection in the Table of
ference of Latitude and Departure.*

IN all Cases of Plain Sailing, there are always
Terms, viz. Course, Distance, Difference
Latitude, and Departure; two of which are
ways given to find the other two; and in the
verse Table, the Course is to be found in the Deg-
Points, or Quarter Points, at the Top of each
The Distance is found in the first and last Column
each Page, and the Difference of Latitude and
parture are found in the rest of the Columns in
Body of each Leaf Side; and which two of the
soever you have given, they being found in their
per Places, the two required Terms may also be
in the corresponding Columns: I shall instance
Examples of all the six Cases of Plain Sailing.

CASE I. *Course and Distance given, to find Difference
of Latitude and Departure.*

A Ship sails S. 25 Deg. E. 96 Miles, I demand
Difference of Latitude and Departure.

In this Table, the left Hand Page in the Columns of Distance proceeds from 1 to 50, and the right Hand Page from 50 to 100; and the given Distance here being above 50, viz. 96, look along the Top of the right hand Pages till you find 25 Deg. and right under it, and against 96, the Distance you find $87^{\circ} 0'$ for the Difference of Latitude, and $40^{\circ} 6'$ for the Departure, as the Title at the Top directs.

But suppose your Course had been South 65 Degrees East, you find 65 Degrees at the Bottom of the same Column where you find 25 at the Top, and against 96, the Distance, you find Difference of Latitude, and Departure the same, viz. $87 : 0$, and $40 : 6$, only with this Alteration, that now $87 : 0$ is the Departure, and $40 : 6$ is the Difference of Latitude; whereas before it was contrary: But to avoid Mistakes herein; observe where you find the Degree of Course, whether at the Top or Bottom of the Table, there find also the Title of the Columns of Difference of Latitude and Departure: Thus, in the first Example of 25 Degrees, you find the Degree at the Top, and therefore the Title also at the Top shews, that the first of the two Columns is Difference of Latitude, and the second the Departure; but in the second Example of 65 Degrees, you find the Degree at the Bottom; and therefore the Title being also found at the Bottom, shews that the first Column is the Departure, and the second the Difference of Latitude, &c.

But suppose my Distance be above 100 Miles, as in the first Example of *Plain Sailing* in this Book, which is, A Ship sails N.W. by N. 123 Miles, I determine her Difference of Latitude and Departure. Here, because the Table reaches but to 100, you take it out at twice; thus the Course being N. by N. 3 Points, I look for 3 Points, which I find at the Top of the Leaf, and under it against 100, I

H

Diff.

	Diff.	Lat.	Dep.
	81	: 1	55 : 1
Then against 23 I find under 3 Points	19	: 1	12 : 1
	102	: 2	68 : 1

These Sums added severally, give 102 : 2 for the Difference of Latitude, and 68 : 4 for the Departure.

But suppose your Distance were so great a Number that it would require to be taken out at a great many Times, as in the Question in Case I. of *Mercator Sailing Trigonometrical*, A Ship sails 987 Miles N. by N. &c. you may also take this out at twice; having found 3 Points, you may take out first for 98 and then for 7 thus; look under three Points, till you come down against the Distance 98, and against you have 81 : 5, for Difference of Latitude, and 54 : 4, for the Departure; but because the 98 is advanced a Figure or Place towards the Left Hand, called 980, therefore advance the other also a Place towards the left Hand, then will the Diff. of Latitude, 81

Diff. Lat. Dep.

815 544

5 : 8 3 : 9

820 : 8 547 : 9

become 815, and the Departure, 54 : 4, will be 544; then finding also for the 7, because the whole Distance is 987, the Work will stand as in the Margin, the Difference of Latitude 820 : 8, and Departure, 547 : 9.

Another Method very proper when your given Distance exceeds what is found in the Table, is to take $\frac{1}{2}$, $\frac{1}{3}$ or $\frac{1}{4}$ &c. of your given Distance, and find the Diff. of Lat. and Departure belonging to that, which being doubled, if you took half, or tripled, if you took one Third, or multiplied by 4, if you took one Fourth &c. of the given Distance; the Numbers so found for the

shall be the Difference of Latitude and Departure requir'd.

Example.

A Ship sails S.S.W. 120, I demand Diff. Latitude and Departure.

Here, because the Table goes not so far as 120, I take the Half of it, viz. 60, and against it, under two Points (because S. S. W. is two Points from the Meridian) I find 55 : 4, for Difference of Latitude, and 10 : 0, for the Departure ; which two Numbers being doubled, (because I took but Half the Distance) becomes 110 : 8, for the Difference of Latitude, and 20 : 0, for the Departure, &c.

CASE II. *Course and Difference of Latitude given, to find Distance and Departure.*

A Ship sails North 38 deg. Westerly till her Difference of Latitude be 120 Miles ; I demand her Distance and Departure.

Because 120 is not to be found in the Table, I take Half of it, viz. 60, and finding 38 deg. at the Top, I look under it till I find 60 under [Lat.] for Difference of Latitude, and right against it, in the Column of Distance, I find 76, which doubled is 152, the Distance requir'd, and against it, under [Dep.] I find 48, which doubled is 96 : 0, the true Departure required.

CASE III. *Course and Departure given, to find the Distance and Difference of Latitude.*

A Ship sails S. W. by S. till her Departure be 40 Miles, I demand Distance and Difference of Latitude.

Find 3 Points at the Top, and under it, in the Column of Departure, find 40, against which you find 59 : 8, for the Distance, and 59 : 8, for the Departure.

CASE IV. *Distance and Difference of Latitude given, to find Course and Departure.*

A Ship sails 71 Miles in the S. W. Quarter, her Difference of Latitude 59 Miles. I demand Course and Departure.

Look for 71 in the Column of Distance, and run over the several Columns of your Table, till you find 59 in one of the other Columns against it, which being found, observe where you find the Title [Lat.] whether at the Top or Bottom of the Table; for there you find also the Course, as in this Example. I run over the Table, till against 71, I find 59 : 0, and the Title [Lat.] being at the Top, I find also the Course at the Top, *viz.* 3 Points, or S.W. by S. and Departure 39 : 4.

CASE V. *Distance and Departure given, to find Course and Difference of Latitude.*

A Ship sails between the South and East 100 Miles, her Departure 53 Miles, I demand the Course and Difference of Latitude.

Look for 100 in the Column of Distance, and against it run over your Table till you find 53 for Departure, and over it you find 32 Degrees for Course, and 84 : 8, for the Difference of Latitude required.

CASE VI. *Difference of Latitude and Departure given, to find Course and Distance.*

A Ship sails between the N. and E. till her Difference of Latitude be 56 : 0, and her Departure 35 : 0, I demand the Course and Distance.

Look through the Columns of Diff. of Lat. and Departure, till you find 56 : 0, against 35 : 0, and there that you find 32 Degrees for the Course, and 66 Miles for the Distance, &c.

Art. 2. *Traverse Sailing by Inspection.* 101

Note, You cannot always find exactly the Numbers
en, but find the nearest you can, which will gene-
ly be of sufficient Exactness for common Use.

SECT. II.

*How to work a Traverse by the Tables of Difference
of Latitude and Departure.*

THIS is the principal Thing for which these
Tables are of Use, and this Way of working a
Traverse is equal to the best for Exactness, and much
more expeditious, and therefore I have of Purpose o-
mitted Traverse Sailing in the Geometrical Part here-
in, as being too tedious for Practice at Sea.

I shall instance in Question the first of *Traverse Sail-
ing Geometrical*, and shall solve the same here by the
Tables.

A Ship sails S.S.E. 30 Miles, then N.E. by N. 40
Miles, then E. by N. 25 Miles, then N. N. E. 44;
Find the Course, Distance, Difference of Lat-
itude and Departure, from the Place sail'd from.

First, Make a little Table with 6 Columns, as you
see in the following Page.

- The first is the Course.
- The second the Distance.
- The third the Northing.
- The fourth the Southing.
- The fifth the Easting.
- The sixth the Westing.

H 2

Course

Course.	Dist.	North.	South.	East.	West.
S. S. E.	30		27 : 7	11 : 5	
N. E. by N.	40	33 : 3		22 : 2	
E. by N.	25	4 : 9		24 : 5	
N. N. E.	44	40 : 6		16 : 8	
		78 : 8	27 : 7	75 : 0	
		27 : 7			
		51 : 1			

Then, by *Case I.* find the Difference of Latitude and Departure to every Course, and set them in proper Columns; as where the Course is Northerly, set the Difference of Latitude under Northing, the North Column; and where the Course is Southerly, set the Difference of Latitude in the South Column.

Again, when the Course is Easterly, set the Departure in the East Column, and when the Course is Westerly, set the Departure in the West Column; then adding up each Column by it self, subtract the North and South Columns, the greater from the lesser, the Remainder is the Northing or Southing made good. Also subtract the East and West Columns, the bigger from the lesser, the Remainder is the East or Westing made good; then have you Difference of Latitude and Departure given, to find the Course and Distance, by *Case VI.*

In this Example, the first Course is S. S. E. 30 Miles, or two Points 30 Miles; for which, by *Case I.* find the Difference of Latitude 27 : 7. Now the Course being between South and East, I place

Sect. 2. *Traverse Sailing by Inspection.* 103

Difference of Latitude in the South Column, and my Departure 11 : 5, in the East Column, leaving the North and West Columns blank.

Then for the second Course, N.E. by N. or 3 Points; 10 Miles, here my Difference of Latitude, 33 : 3, to be placed in the North Column, and the Departure, 22 : 2, in the East Column, because the Course is between the North and East.

Then the third Course being E. by N. or 7 Points; 10 Miles, I place my Difference of Latitude, 4 : 9, in the North Column, and Departure, 24 : 5, in the East Column.

And so for the fourth Course, N.N.E. or 2 Points; 10 Miles, I place my Difference of Latitude, 40 : 6, in the North Column, and my Departure, 16 : 8, in the East Column, and then adding up each Column,

the Sum of the Northing Column is 78 : 8, and the Sum of the South Column is 27 : 7, which subtracted from the Northing, 78 : 8, the Remainder, 51 : 1, is

the Difference of Latitude made good, which is Northing, because the Northing was the greater Number,

Again, the Sum of the Easting Column is 75 : 0.

Which (because there is no Westing to subtract from) is the Easting made good. Thus you have the

Northing, 51 : 1, and the Easting, 75 : 0, given,

find Course and Distance, by Case VI. and although you cannot find in the Table the exact Num-

bers of 51 : 1, and 75 : 0, together, yet find the

next you can, which is 75 : 4, and 50 : 9, over

which, at the top, you find 34 Degrees for the Course,

which is N.E. by N. $0^{\circ} 15'$ Easterly, and the Distance

10 Miles.

But if you have a Place propos'd that you are bound

to, whose Course and Distance from the Place sail'd

from is given, find thereby the Difference of Latitude

and Departure to the Place bound for, from which

subtract the Difference of Latitude and Departure,

made good, (if it be the lesser Number, or the other

from it, if one of them be the greater Number) the Remainder is the Difference of Latitude and Departure from the Ship to the Place bound for, by which you may find the Course and Distance by *Case VI.*

Example. In the first Question in *Traverse Sailing Geometrical*, there is a Place proposed to be sail'd distant 120 Miles N.E. $\frac{1}{2}$ E. the Difference of Latitude for that Course and Distance is found by *Case I.* to be 76 : 2, and the Departure, 92 : 8. Now the Difference of Latitude made good by the Ship being 51 : 1, if subtracted from the whole Difference of Latitude to the Place bound for, 76 : 2, it is evident that the Remainder, 25 : 1, must be the Difference of Latitude from the Ship to the Place bound for. And so the Departure made good by the Ship, 75 : 0, subtracted from the whole Departure, 92 : 8, the Remainder, 17 : 8, is the Departure from the Ship to the Port bound for. And thus you have the Difference of Latitude, 25 : 1, and the Departure, 17 : 8, to find the Course and Distance by *Case VI.* and the nearest to these two Numbers that can be found is 25 : 1 and 17 : 8, over which you have 35 deg. for the Course, and against it, 31 Miles for the Distance viz. N.E. by N. $1^{\circ} 15'$. Easterly, 31 Miles is the Course and Distance to the Place bound for, &c.

But suppose the Difference of Latitude made good by the Ship were more than the Difference of Latitude to the Port bound for, you must subtract the lesser from the greater, and the Remainder is the Difference of Latitude from the Ship to the Port, but of contrary Denomination, which seems to be so plain that it needs no Example; for if a Man intends to travel to a Place that bears due N. from him 12 Miles, if the Man travels 15 Miles due North, his Course from thence to the Place bound for is South 3 Miles; even so if a Ship intending for the Port aforesaid whose Difference of Latitude is 76 : 2 North, and Departure 92 : 8 East, should sail between

Now

h and East, till her Difference of Latitude be North, and Departure 75 : 0 East, 'tis plain she is the Northward of her Port; because she has got the Difference of Latitude Northerly; and she is all the Westward of her Port, because she hath not so much Departure Easterly; and therefore subtracting the bigger Difference of Latitude from the the Remainder, 23 : 8, is the Difference of Latitude Southerly from the Ship to the Port bound for; the Departure, 75 : 0, subtracted from the whole Departure, 92 : 8, the Remainder, 17 : 8, is the Departure Easterly from the Ship to the Port bound for, in this Case the Course and Distance would be by Case VI. to be S.E. by S. 29 : 5 Miles.

SECT III.

to find the Difference of Longitude by the Table of Difference of Latitude and Departure.

Having one Latitude, Course and Distance, given, or both Latitudes and Course, &c. you may find the rest according to *Plain Sailing*, by the foregoing Rules, which being done, find the middle Latitude, (always observing that Caution, to take a Latitude rather too big than too little, where the middle Latitude cannot exactly be had without a Fraction)

the Rule is :

Find the Complement of middle Latitude amongst Degrees at the Top or Bottom of the Table, and set it, (if you find it at the Top, or above it, if you find it at the Bottom) in the Column of Departure, find your Departure, and right against it, in the Column of Distance, is the Difference of Longitude.

And

And altho' this Method is not so practicable in great Numbers, yet it is very useful at Sea, for working Day's Run, or the like, which seldom exceeds 50 or 60 Leagues; and therefore I shall recommend it to the Learner, as the most expeditious Method, and sufficient Exactness for short Distances; here be the Methods sufficient laid down in this Treatise for exactly correcting the Reckoning once or twice in a Week, of which more when we come to that Part.

Note, If you think it too much Trouble to subtract the middle Latitude from 90, to find its Complement, you may find the middle Latitude amongst the Degrees, as before: and find the Departure in the Column of Difference of Latitude, and against it in the Column of Distance, you have the Difference of Longitude as before.

I shall give an Example or two, and refer the Reader for further Practice of this Method, to the Examples laid down for keeping a Reckoning in the latter Part of this Book, where I shall illustrate this Method by Example, and shew its general Agreement with the Longitude, as found by *Mercator's Sailing*.

Example 1. A Ship in Latitude $55 : 0$ North sails in the North-East Quarter, into Latitude $56 : 0$ North, her Departure 50, I demand Course, Distance, and Difference of Longitude.

See the same Question in *Case IV.* of Middle Latitude sailing Trigonometrical.

Difference of Latitude 70, Departure 50, the Course will be found by *Case VI.* hereof to be 36 Degrees nearest, omitting the Minutes, and the Distance 80.

The Middle Latitude is $55 : 35$, but because we have only whole Degrees, we must use either 55 Degrees, or 56 ; and because, as I said before, 'tis better to take a Degree too great rather than too little, we shall call it 56 , whose Complement 34 found in the Table of Degrees, look under it for the Departure 50, the

Nearest Number to which is $49 : 8$, against which in the Column of Distance, I find 89 for the Difference Longitude required.

Example 2, in Case V. of Middle Latitude Sailing trigonometrical.

I demand the Course, Distance, and Difference of Longitude between two Places, one in Latitude $56 : 15$ North, the other in Latitude $58 : 35$ North, their Meridian Distance 81.

Difference of Latitude 140, Departure 81, the Course is found by *Case VI.* to be an Angle of 30 Degrees from the Meridian, and the Distance 162, as you may see by the Traverse Table.

Then for Difference of Longitude, the Middle Latitude is $57 : 25$, but we must call it in this Case 58, which found in the Degrees, there is not such a Number as 81 in the Column of Latitude, therefore find the half, $40 : 5$, or the nearest to it, which is $40 : 3$, and against it, in the Column of Distance, you find 66, which doubled is 132, the Difference of Longitude required.

Note, Although in particular Questions the Longitude found this Way differs sometimes a Minute or two from that found by Calculation; because we are obliged to use whole Degrees in Table for Middle Latitude; yet the Error being sometimes a Minute or two too much, and sometimes as much too little, the Difference is not discernable in a long Reckoning.

C H A P. IV.

Arithmetical Navigation.

S E C T. I.

Plain Sailing Arithmetical.

HAVING thus finished all the Kinds and Cases of Navigation in the foregoing Book, according to the Method commonly taught and practised both at Sea and a-shore, viz. by a Canon of Logarithmical Sines, Tangents and Secants, (together with the Help of the Logarithms of Natural Numbers) my next Work is (according to my Promise) to shew how all the aforesaid Kinds of Navigation may be compleatly performed without any Canon, only by the Help of some given Numbers, which shall be inserted in their proper Places, which are of Use when the Course is either given or required: And first in order I shall begin with *Plain Sailing*, in which the three first Cases are wrought only by the Table of given Numbers, as also are those Questions in the three last Cases where the Course is required: But the Solution of all Questions in *Plain Sailing*, when two Sides are given to find a third (as Distance and Difference of Latitude given to find Departure, &c.) are grounded upon that known Proposition in *Euclid*, Lib. 1. Prop. 47, viz. That the Square of the Hypotenuse (called there the Base, because it is the longest Side) of a right-angled Triangle, is equal to the Squares of both

h Legs added together. Hence then (the Hypotenuse representing the Distance, and the two Legs the Difference of Latitude and Departure) if you square each Leg (that is multiply each Leg by its self) the two Sums added together shall be equal to the Square of the Hypotenuse; and consequently, if from the Square of the Hypotenuse you subtract the Square of one Leg, the Remainder is the Square of the other Leg, as may be proved by those three known Numbers, 3, 4, and 5, which three Numbers make a right-angled Triangle; the two Legs being 3 and 4, and the Hypotenuse 5: Now if you square the two Legs, 3 times 3 is 9, and 4 times 4 is 16, which two Squares 9 and 16 added together, the Sum is 25, the Square of the Hypotenuse. Again, if from 25, the Square of the Hypotenuse, you subtract 16, the Square of one Leg, there remains 9, the Square of the other Leg, &c. And when the Square of any Side is thus found, the square Root thereof (found as is shewn in the first Part hereof) is the Side required.

Also with respect to the given Numbers, if Course and Distance be given, multiply the Distance by the given Numbers, as the Title of the Table directs for Latitude and Departure, (whose Use follows in several Examples) the Sum, abating as many Figures to the right Hand as you multiply by, is the Difference of Latitude or Departure required: Now if the Hypotenuse multiplied by the given Number produce a Sum, only two Figures to be cut off the said Leg being given, and two Figures (or Cyphers) added to it, and divided by the said given Number, the Quotient must need be the Hypotenuse; and if so, then if the said Leg with two or more Figures (or Cyphers) added to it be divided by the Hypotenuse, the Quotient must needs be the given Number, as is apparently evident to almost every body that have but learned the Rudiments of Arithmetick, and understand (what every Schoolboy is taught) how Multiplication and

Divi-

Division will undo and prove each other ; and any two Parts of a Question of *Plain Sailing* being given, the rest may be found by the Square-root, one Table of given Numbers, all the Cases of the sixth being wrought immediately by the Numbers ; and even in the sixth Case, where the Legs are given, the Hipotenuse or Distance may be found by the square Root, and then the Course, and the other Cases ; as I shall explain by the following Examples.

A TABLE of Given Numbers.

Points	Latitude	Depart.	Points
0 $\frac{1}{4}$	99 : 88	04 : 88	7 $\frac{3}{4}$
0 $\frac{1}{2}$	99 : 52	09 : 76	7 $\frac{1}{2}$
0 $\frac{3}{4}$	98 : 92	14 : 66	7 $\frac{1}{4}$
1	98 : 08	19 : 51	7
1 $\frac{1}{4}$	97 : 01	24 : 27	6 $\frac{3}{4}$
1 $\frac{1}{2}$	95 : 71	28 : 99	6 $\frac{1}{2}$
1 $\frac{3}{4}$	94 : 15	33 : 71	6 $\frac{1}{4}$
2	92 : 39	38 : 27	6
2 $\frac{1}{4}$	90 : 40	42 : 77	5 $\frac{3}{4}$
2 $\frac{1}{2}$	88 : 20	47 : 13	5 $\frac{1}{2}$
2 $\frac{3}{4}$	85 : 79	51 : 38	5 $\frac{1}{4}$
3	83 : 15	55 : 56	5
3 $\frac{1}{4}$	80 : 33	59 : 55	4 $\frac{3}{4}$
3 $\frac{1}{2}$	77 : 29	63 : 45	4 $\frac{1}{2}$
3 $\frac{3}{4}$	74 : 10	67 : 15	4 $\frac{1}{4}$
4	70 : 71	70 : 71	4
Points	Depart.	Latitude	Points

The Use of this Table is for working the six Cases of *Plain Sailing*, in which I serve, that in the first and last Column, I have the Rumbs of the Compass, with the Points, and quarter Points, number'd from the Merid. or North and South Line, whether East or West, according as they stand in order ; thus S. S. is two Points, because South is upon the Meridian, then S. by E. is one Point, and S. W. two Points, &c. So likewise N. N. E. and N. N. W. is one Point from the North. Again, suppose a Ship sails S. W. $\frac{1}{4}$ S. that is three Points and

and N. N. E. $\frac{1}{4}$ E. is two Points and a Quarter; being a Thing so commonly known, I shall not to add any more Examples.

When the Number of Points thus found, observe on which of the Table it is found; for if you find the Course on the left Hand, then find the Denomination of Latitude and Departure at the Top: But if the Course be on the right Hand, find the Denomination of Latitude and Departure at the Bottom; for the left hand Column contains all the Points under four Points, and the right hand Column contains all the rest of the Points to 8. Now if the Course be found in the first Column, (*viz.* less than four Points) then the second Column is the given Number for Difference of Latitude, and the third Column is the given Numbers to find Departure: But if the Course be in the last Column, (*viz.* above four Points) then the third Column is the given Numbers to find Difference of Latitude, and the second is for the Departure, &c. And the Use of the Table being thus known for the first Time, the rest is easily found by Consequence, as we hinted before, and shall make it evident and intelligible to the meanest Capacity, by the following Examples.

Example. If you have a given Number, with a Cypher at the left hand, (as in $7\frac{1}{2}$ and $7\frac{1}{4}$ Points) although the Cypher adds nothing to the Product (being on the left hand) yet it causeth a Figure more to be cut off the Decimal Fraction; and having cut off as many Figures towards the right hand as you multiply by, the rest is the Latitude or Departure sought, and those cut off are a Numerator of a Decimal Fraction to a Denominator consisting of as many Cyphers as you cut off Figures, with a 1 at the left hand; so if you cut off $7\frac{1}{2}$, it is $\frac{27}{100}$, or if you cut off $7\frac{1}{4}$, it is $\frac{342}{1000}$, and so of the rest.

Note. When you have found the given Number in the Table, you need not always use all the 4 Figures, especially,

especially if the third or fourth be a small Digit, or 2, as suppose your given Number be 8315, the third Figure being a 1, you may cut off the last Figures, and use only 83, to work with. Again if the third Figure be one of the highest Digits, or 9, you may cut off the two last, only add on the second Figure, and so work as before; as suppose your Number be 2899, you may add 1 to the second Figure, *viz.* 8, and then cut off the two last, then your Number to work with will be 29; Reason of all which is very evident to any that understand the Nature of Decimals, and will by a little Practice become easy to the meanest Capacity.

Plain Sailing.

CASE I. *Course and Distance given, to find the Difference of Latitude and Departure.*

The Rule.

Multiply the Distance by the given Numbers of the Course, and from the Product cut off as many Figures as you multiply by, and the rest is Difference of Latitude and Departure required.

Question. A Ship sails N. W. by N. 123 Miles demand her Diff. of Latitude and Departure.

The given Number for Diff. Latitude being 83, we shall only use 83, and cut off the other two Figures (towards the right hand,) and multiplying Distance 123, by the given Number 83, and from the Product cut off two Figures, (because you multiply two Figures) you have Difference of Latitude; for Departure the given Number is 5556, the third Figure being a 5, we shall for more Exactness use the first three Figures, *viz.* 555, and work as before: The Operation for Difference of Latitude and Departure stand thus:

For Diff. of Latitude.

For Departure.

$$\begin{array}{r} 123 \\ 83 \\ \hline \end{array}$$

$$\begin{array}{r} 123 \\ 555 \\ \hline \end{array}$$

$$\begin{array}{r} 369 \\ 984 \\ \hline \end{array}$$

$$\begin{array}{r} 615 \\ 615 \\ \hline \end{array}$$

$$102|09$$

$$68|265$$

The Difference of Latitude is $102.\frac{9}{100}$, the Departure is $68.\frac{265}{1000}$; but you need not regard the Fractions, only if a Fraction be considerably above half of a Mile, or Minute, you may add 1 to the whole Number; as suppose your Fraction be 78, viz. $\frac{78}{100}$, you may add 1 to the whole Number, and reject the Fraction, &c.

Another Example in Case I.

A Ship sails N.N.W. $\frac{1}{2}$ W. 165 Miles, I demand the Difference of Latitude and Departure.

N.N.W. $\frac{1}{2}$ W. is 2 $\frac{1}{2}$ Points:

For Diff. of Lat.

For Depart.

$$\begin{array}{r} 165 \\ 88 \\ \hline \end{array}$$

$$\begin{array}{r} 165 \\ 47 \\ \hline \end{array}$$

$$\begin{array}{r} 1320 \\ 1320 \\ \hline \end{array}$$

$$\begin{array}{r} 1155 \\ 660 \\ \hline \end{array}$$

$$145|20 \text{ Diff. Lat. } 145.$$

$$77|55$$

Dep. 77, or rather 78, because the Fraction is $\frac{78}{100}$.

1

CASE

CASE H. *Course and Difference of Latitude given to find Distance and Departure.*

The RULE.

For the Distance, add as many Cyphers to the Difference of Latitude as the Number of Figures you think to make Use of in the given Number, and divide it by the given Number, and the Quotient is the Distance, which being found, find the Departure as in Case I.

Question. A Ship sails S. W. by S. till her Difference of Latitude be 174; I demand the Distance and Departure.

The Course is 3 Points, the given Number is 174, and 5556.

For the Distance.

For Departure.

83)17400(209 Dist. W. by S. 174
..800

94

1045

1045

215995

The Distance 209, and Departure 115, or 116, because the Fraction is so great, viz. above

CASE III. Course and Departure given, to find Distance and Difference of Latitude.

The RULE.

Add so many Cyphers to the Departure as you wish to use Figures in the given Number; and then divide by the given Number answering to Departure, the Quotient is the Distance, which being found, the Difference of Latitude, as in Case I.

Question. A Ship sails N. by E. $\frac{1}{2}$ E. till her Departure be 72, her Distance and Difference of Latitude required.

Example the second, in Case III. of Plain Sailing.

For the Distance.

$$\begin{array}{r} 337 \overline{) 72000} (214 \\ \underline{.460} \\ 1230 \\ \underline{1152} \\ 219 \end{array}$$

For Diff. Lat.

$$\begin{array}{r} 214 \\ 94 \\ \hline 856 \\ 1926 \\ \hline 20116 \end{array}$$

The Distance is 214, (being so large a Fraction)
The Difference of Latitude is 201.

CASE

CASE IV. *Distance and Difference of Latitude given
to find the Course and Departure.*

The RULE.

Square the Distance (that is, multiply it by it self) and likewise the Difference of Latitude, and subtract the lesser Number from the greater, the square Root of the Remainder is the Departure required, and for the Course, add two or three Cyphers to the Difference of Latitude, and divide that Sum by the Distance, the Quotient is the given Number for the Course, which being found in the Table, you have gainst it the Course required.

Note, If you cannot find exactly the same Number (which seldom happens) find the nearest to it, which is sufficient, and find the Course to the nearest Quarter Point.

Question. A Ship sails between the North and South 110 Miles; and then finds by Observation, that she hath rais'd the Pole 1 Degree, or 60 Min. or more. I demand the Course and Departure.

For the Course.

110)60000 (545
 .50
 .600
 ———
 .50

110
 110
 ———
 1100
 110
 ———
 12100

For the Departure.

60 Sq. of Dist. 3600
 60 Sq. of D. Lat. 3600
 ———
 3600
 1100
 ———
 2500
 110
 ———
 8500 (92
 81
 ———
 182)400
 364
 ———
 36

The Quotient 545 sought in the Table, the nearest even Number is 555, and against that, for the Course, you have five Points, which are N. E. by E. because the Course is between North and East, and the Departure is 92, for you need not regard the Fraction the Square Root, it being but a small Part of a Degree or Minute in the Departure.

Case V. Distance and Departure given, to find Course and Difference of Latitude.

The RULE.

Subtract the Square of the Departure from the Square of the Distance, the Square Root of the Remainder is the Difference of Latitude; and then find the Course as in Case IV; only mind to find the Quotient in the Departure Column.

Question. A Ship sails in the S. W. Quarter 124 Miles, her Departure 95, I demand the Course and Difference of Latitude.

For the Course.

For the Diff. of Lat.

95000	(766	124	95	Square of Dist. 15376
.82		124	95	Sq. of Diff. Lat. 9025
.760		—	—	Diff. of Squares 6351
—		496	475	
16		248	855	6351(79
		124	—	49
		—	9025	149)1451
		15376		1341
				110

The Course is S.W. $\frac{1}{2}$ W. nearest; for the nearest even Number to the Quotient 766 is 772, which is the Number for 4 $\frac{1}{2}$ Points, or S.W. half W. and the Difference of Latitude is 79, or rather 80, because the Remainder of the Square Root is so great: And to observe, for a general Rule, that because the last Remainder in the Extraction is a Numerator to twice the Root, for a Denominator; therefore if the last Remainder be more than the Root, add one to the Root, and that will be the Root exact enough in this Case; but if the Remainder be less than the Root found, the Root is the nearest whole Number that answers the Question, and you need not regard the Fraction at all. Thus in the Example, *Case IV.* the Root is 92, and the Remainder is but 46, and therefore I keep 92 for the Departure, and reject the Fraction. But in the Example in *Case V.* the Root is 79, and the Remainder is more than the Root, *viz.* 110; and therefore I add 1 to 79, and the Sum 80 is the Difference of Latitude required, and so in others.

CASE VI. *Difference of Latitude and Departure given, to find the Course and Distance.*

The RULE.

Square the Difference of Latitude, and also the Departure, and add the two Squares together; the Square Root of the Sum is the Distance required; and to find the Course, as in *Case IV.* or *Case V.*

Question. A Ship sails in the N. W. Quarter, her Difference of Latitude be 220, and her Departure 108, I demand the Course and Distance.

For the Distance.

220	108	Square of Diff. Lat.	48400
220	108	Square of Departure	11664
44	864	Sum of the Squares	60064
44	1080		
48400	11664		
			60064(245
			4

For the Course.

245	220000	(827	485	2464
	2400			2425
	1950			
				39
	235			

The Course is 2 Points and a Quarter, or N. N. W.
 the Distance 245 Miles.

Although the Operation in this Case seems the most
 tedious of all the rest, because we have assumed great
 Numbers for the Data of the Question, yet even in
 the greatest Number this Way is much more expedi-
 ent than working by a Canon, as a little Practice
 will make manifest.

SECT. II.

Mercator's Sailing Arithmetical.

WHAT I have writ of *Plain Sailing* is also Use in *Mercator's Sailing*, so far as Course, Distance, Difference of Latitude, and Departure, Terms either given or required; and the same Table of given Numbers is of equal Use in both; and as the Difference of Longitude, it bears the same Proportion to the Departure, that the Meridional Difference of Latitude bears to the true Difference of Latitude, by *Euclid. Lib. 6. Prop. 4.* and indeed by Help of a Table of Meridional Parts, the whole Practice of *Plain Sailing*, as performed by given Numbers, may be reduced to *Mercator*, by *Euclid. Lib. 6. Prop. 4.* For being both projected by a plain Triangle and the Course, whether given or required, bears the same in both; there must needs be the same Proportion between the enlarged Distance, and the true Distance, (being supposed to be the Hypotenuses of equiangular Triangles) or between the Difference of Longitude and Departure, (the Perpendiculars of the said 2 equiangular Triangles) as there is between the Meridional Difference of Latitude, and the true Difference of Latitude, (being the Bases of the said 2 Triangles) and upon these Propositions, the whole Fabrick of *Mercator's Sailing* is grounded; the Truth of which is prov'd not only by the Demonstration of *Euclid*, in the Propositions above-named; but also by comparing the Questions thereby performed to those in the first Part, performed by a Canon, which I shall, for the Reader's Satisfaction, relate to the said Questions, as in the following Examples.

SE I. One Latitude, Course and Distance, given, find the other Latitude, Departure, and Difference of Longitude.

The RULE.

Find the Difference of Latitude and Departure, as in I, of Plain Sailing Arithmetical; and then for Difference of Longitude, the Proportion is, As proper Difference of Latitude to Meridional Difference of Latitude; so Departure to Difference of Longitude.

Question. A Ship in Lat. $50^{\circ}00'$ North, sails N. by N. 987 Miles, I demand the Latitude come together with her Departure, and Difference of Longitude.

For Diff. of Latitude.

987
83

2961
7896

819121

For Departure.

987
555

4935
4935

4935
547785

Diff. Lat. 819 or rather 820, Departure 548, merid. Diff. Lat. 1519, then for Diff. Longitude;
As 820 to 1519, so 548 to Diff. of Longitude.

1519
548

12152
6076

7595
832412

820)832412(1015
.124

4212

112

CASE

CASE II. Both Latitudes and Course given, to find Distance and Departure, and Difference of Longitude.

The Rule.

Find the Distance and Departure, as in Case second of *Plain Sailing Arithmetical*, and then find Difference of Longitude, as in the first Case of *Mercator's Sailing*.

Question. A Ship sails from St. Abbs Head in Latitude $56^{\circ} 35'$ North, and sails away N.N.E. for 4 Days, and then finds herself by Observation in Latitude $63^{\circ} 30'$ North; I demand how far he hath sailed, and what is his Difference of Longitude.

For the Distance.

For the Departure.

$$\begin{array}{r} 924)725000(784 \\ \underline{.7820} \\ 4280 \\ \underline{584} \end{array}$$

$$\begin{array}{r} 785 \\ \underline{383} \\ 2355 \\ \underline{6280} \\ 2355 \\ \underline{700655} \end{array}$$

As 725 to 1593, so 300 to Diff. Longitude.

$$\begin{array}{r} 725)477900(659 \\ \underline{300} \\ 477900 \\ \underline{4290} \\ 6650 \\ \underline{125} \end{array}$$

The Distance is $784 \frac{3}{4}$, or rather 785, the Departure 300, and the Difference of Longitude 659 or 660.

CASE III. One Latitude, Course, and Difference of Longitude given, to find the other Latitude, Distance, and Departure.

The RULE.

Add so many Cyphers to the Difference of Longitude as you intend to use Figures in the given Number divide by, and work as in Case III, of Plain Sailing Arithmetical; only observe, that whereas the Quotient there is the true Distance, because you work by Departure; here the Quotient is the enlarged Distance of the whole Hypotenuse, contained between the Angle of the Course, and the Top of the perpendicular, representing the Difference of Longitude, and then the enlarged Distance being found from the Square of the enlarged Distance, subtract the Square of the Difference of Longitude, the Square Root of the Remainder is the Meridional Difference of Latitude, which being found, and one Latitude given, the other Latitude is easily found: Then for Departure, it is only the former Proportion inverted, viz. As Meridional Difference of Latitude to proper Difference of Latitude, so Difference of Longitude to Departure.

Question. A Ship in Lat. $55^{\circ} 00'$ North, sails N. half W. till her Diff. of Longitude be 1 Deg. or 60 Min. I demand the Distance, Departure, and Latitude come to.

For the enlarged Distance.

6000	(127 $\frac{1}{2}$)	Squ. of the enlarg'd Distance	16285
120		Square of Diff. of Longitude	3600
360			
		Difference of the Squares	12685
31			12685

12685(112

I

21)026

21

222)585

444

141

Merid. Parts of Lat. sail'd from $55^{\circ} 00'$ — 396

Merid. Diff. Lat. add ————— 111

Merid. Parts of Lat. come to — 56 04 — 408

As Merid. Diff. Lat. 113 to proper Diff. Lat.
so is the enlarged Diff. 128, to the true Diff. 74

128

64

512

768

8192

113)8192(72

282

56

For the Departure.

As Mer. Diff. Lat. 113, to proper Diff. Lat. 64
Diff. Longitude 60, to Departure.

64

60

113)3840(33

450

3840

111

Dep. 33, or rather

CAS

CASE IV. Both Latitudes and Distance given, to find the Course, Departure, and Difference of Longitude.

The RULE.

Find the Course and Departure, as in Case IV, of Sailing Arithmetical, and then find Difference of Longitude, as in Case I, of Mercator's Sailing Arithmetical.

Question. A Ship in Lat. $55^{\circ} 00'$ North, sails between the North and East 86 Miles, and then is by Observation in Lat. $56^{\circ} 10' N$. I demand as above.

See the same Question in Mercator's Sailing, Case V.

For the Departure.

86	Sq. of Dist.	7396	2496(49
86	70	Sq. of Dep.	4900
—	70	—	16
516	—	Diff. of Sq.	2496
688	4900	—	89)896
—	—	—	80
7196	—	—	95

For the Course

For Difference of Longitude.

70000(812	As 70 to 124, so 50 to Diff. Long.
120	50
340	70)6200(887
—	600
82	6200
	40

The Departure 50, the Course N. E. $\frac{1}{2}$ N. the Diff. of Longitude 88 $\frac{1}{2}$.

CASE

CASE V. Both Latitudes and Departure given,
Find the Course, Distance, and Difference of Longitude.

The RULE.

Find the Course and Distance as in Case VI of *Sailing Arithmetick*; and Difference of Longitude in the first Case of *Mercator's Sailing Arithmetick*.

Question. A Ship in Lat. $55^{\circ} 00'$ North, sails between the North and East into Lat. $56^{\circ} 10'$ North, Departure 50 Miles, I demand the Course, Distance and Difference of Longitude.

For the Distance.

70	50	Sq. of Diff. Lat.	4900	7400(0
70	50	Square of Dep.	2500	64
4900	2500	Sum of Squares	7400	186)7000
				996

For the Course.

For Diff. of Long.

86)70000(813	As 70 to 124, so 50 to Diff. of Long
120	50
340	6200
82	60.
	48

The Course is N. E. $\frac{1}{2}$ N. the Distance 86; Difference of Longitude $88\frac{1}{2}$, or rather 89.

SE VI. *Given Latitudes and Diff. of Longitude given, to find Course, Distance and Departure.*

The R.U.L.E.

square the Difference of Longitude, and also Merid. Difference of Latitude, the square Root of sum of these two Squares is the enlarged Distance: as Merid. Diff. of Latitude to proper Diff. of Longitude, so the enlarged Distance to the true Distance. And then find the Course as in Plain Sailing arithmetical, Case IV.

Question. Suppose two Places, one in Lat. $56^{\circ} 15'$ N, the other in Lat. $58^{\circ} 35'$ N, their Diff. of Long. 150 Min. I demand the Course and Distance from the Southernmost to the Northernmost.

For the Distance.

150	150
150	150
—	—
75	156
15	52
—	—
22500	67600

sq. of Mer. Diff. of Lat.	67600.	90100(300
sq. of Diff. of Long.	22500	9
—	—	—
sum of the Squares	90100	60)001
		000
		—
		600) 100

As

As 260 to 140, so 300 to the Distance. 17 32

2001-26042000(161) For the C

42000 160 161) 14000 1120

the Difference of Latitude, the Square Root of

The Distance 161. The Course N.N.W. 1 W.

CASE VII. One Latitude, Course and Departure given, to find the other Latitude, Distance, and Difference of Longitude.

Suppose one in 1000

Find the Distance by *Case III*, of *Plain Sailing* *metrical*, and Difference of Latitude as in *Case* the same; and Difference of Longitude as in all the other *Cases* hereof.

Question. A Ship in Lat. $58^{\circ} 00'$ North, sails W. $\frac{1}{2}$ W. till her Departure be 60 Miles, I demand above.

For the Distance.

For Diff. of Lat.

47)6000(127

120

360

31

127

127

889

254

127

16129

60

60

2600

$$\begin{array}{r}
 \text{Square of Distance} \text{ --- } 16129 \\
 \text{Squ. of Departure} \text{ --- } 3600 \\
 \hline
 \text{Diff. of the Squares} \quad 12529 \quad 21)025 \\
 \hline
 \quad \quad \quad 21 \\
 \hline
 \quad \quad \quad 221)429 \\
 \quad \quad \quad 221 \\
 \hline
 \quad \quad \quad 208
 \end{array}$$

For the Difference of Longitude.

proper Diff. of Lat. 112, to Merid. Diff. of Lat. 206;
so Departure 60 to Diff. of Long.

$$\begin{array}{r}
 206 \\
 60 \\
 \hline
 12360
 \end{array}
 \quad
 \begin{array}{r}
 112)12360(110 \\
 \quad .116 \\
 \hline
 \quad \quad 40
 \end{array}$$

The Difference of Latitude 112 Min. or $1^{\circ} 52'$,
which subtracted from the Latitude sail'd from, because
Course is Southerly, the Remainder is the Lat-
itude come to, $56^{\circ} 8'$; the Distance 127; the Diff. of
Longitude 110.

ASE VIII. One Latitude, Distance, and Departure
given, to find the other Latitude, Course, and Difference
of Longitude.

The RULE.

Find the Course and Difference of Latitude as in
V, of Plain Sailing Arithmetical; then find the
Difference of Longitude as before.

K

Question.

Question. A Ship in Lat. $58^{\circ} 00'$ North, sails between the South and West 127 Miles, her Departure 60, I demand the rest.

For Difference of Latitude.

127		Sq. of Dist. 16129	12529
127	60	Sq. of Dep. 3600	1
	60		
889		Diff. of Sqs. 12529	21)025
254	3600		21
127			
			221)429
16129			221
			208

For the Course

For Difference of Longitude.

127)60000(472	As 112 to 206, so 60 to Diff. Long.	
.920	60	112)12360(110
.310		.116
	12360	
56		.40

The Course S.S.W. $\frac{1}{2}$ W. the Lat. comes to 56° and Diff. of Long. 110.

S E C T III.

Parallel Sailing Arithmetical.

Before I proceed to the Solution of the several Cases of *Parallel Sailing*, I shall insert a Table of ten Numbers, which is equally useful in *Parallel* and *Middle Latitude Sailing*; for by those Numbers the Departure in *Middle Latitude Sailing*, (which is the Distance in a Parallel, or East and West Course) is reduced to Difference of Longitude without any Logarithms, Sines or Tangents, only by one Operation Division, the Use of which Table in *Parallel Sailing* thus:

When you have the Distance in the Parallel given, so many Cyphers to the Distance as you intend to Figures in the given Number, and then divide the by the other, and the Quotient is the Difference Longitude: But if Difference of Longitude, and Latitude is given, multiply the Difference of Longitude by the given Number belonging to that Latitude, and from the Product cut off as many Figures as you multiply by, and the rest is the Distance; and frequently if Distance and Difference of Longitude be given, and Latitude required, add two, three or four Cyphers to the Distance, and divide that Sum by Difference of Longitude, the Quotient found in the Table is the given Number, answering to the Latitude required, &c.

A TABLE of given Numbers for Parallel and Middle Latitude; the given N^o for Lat. 00° 00' being 10000.

Lat.	N ^o	Diff.	Lat.	N ^o	Diff.	Lat.	N ^o	Diff.
19998	2		318572	88		614848	152	
29994	4		328480	91		624695	153	
39986	8		338387	93		634540	155	
49976	10		348290	96		644384	156	
59962	14		358191	99		654226	158	
69945	17		368090	101		664067	159	
79925	20		377986	104		673907	160	
89902	23		387880	106		683746	161	
99877	26		397771	109		693584	162	
109848	29		407660	111		703420	163	
119816	32		417547	113		713256	164	
129781	35		427431	116		723090	165	
139744	38		437313	118		732924	166	
149203	41		447193	120		742756	167	
159659	44		457071	122		752588	168	
169613	46		466946	124		762419	169	
179563	50		476820	126		772249	170	
189511	52		486691	129		782079	171	
199455	56		496560	131		791908	172	
209297	59		506428	133		801736	173	
219234	63		516293	135		811564	174	
229272	65		526157	137		821392	175	
239205	67		536018	139		831219	176	
249135	70		545878	141		841045	177	
259062	72		555735	143		850871	178	
268988	75		565592	144		860697	179	
278910	78		575446	146		870523	180	
288829	81		585299	147		880349	181	
298746	83		595150	149		890174	182	
308660	86		605000	150		900000	183	

Art. 3. *Parallel Sailing Arithmetical.* 133

The Use of this Table of given Numbers for *Parallel* and *Middle Latitude Sailing*, is partly laid down in the page preceeding the Table, and shall be further explained in the several Cases of *Parallel* and *Middle Latitude Sailing*, and the same Cautions are to be observed in the Use of this, that was to be observed in the first Table of Given Numbers, *viz.* that for *Plain Sailing Arithmetical*; for if the third Figure of the Given Number be a Cypher, or 1 or 2, you need use two Figures, (unless your Question be proposed of very great Numbers;) or if the third Figure be 8 or 9, you may add 1 to the second Figure, and so proceed in your Work: But in this Table, as also in that of *Plain Sailing*, if your Question be propounded of Numbers consisting of three or four Figures, it is to use at least as many Figures of the Given Number as there is in the *Data*, or Given Term of your Question, as we shall make evident by the succeeding Examples.

I have set down the given Numbers, only to whole Degrees of Latitude; the Numbers to the intermediate Minutes being easily found, by proportioning the Differences set down in the third, sixth, and ninth Columns of the Table, the Use of which is this: Suppose in a *Parallel Course*, the Latitude of the Parallel (in a *Middle Latitude Question*, the *Middle Latitude*) be 62 Degrees, and I desire to find in the Table, the given Number to that Latitude; I look in the Table under [Lat.] and find 62, and against it, under [Num.] I find 4695, the Given Number required: But if I would find the given Number for Lat. 59° 30', I look for the Number for Lat. 60, and find 5000, and being a Latitude between 59 and 60, I look against under [Diff.] for the Difference, (for the Difference, between the given Numbers for both Latitudes is always against the greater Latitude) and find the Difference is 150, therefore I take half of it, because 30 Minutes is half a Degree, and add

It to the given Number for 60 Degrees, viz. 5075 the Sum 5075 is the Given Number for the Lat. 30', which was required to be known.

Note, the Given Number for Lat. 00° 00' is 10000 and from thence, as the Latitude encreases, the Numbers decrease, so that the Number for Lat. 90 is 0 hence the greater that the Latitude is, the lesser is the Given Number; therefore observe always when you would find the Number to any Latitude consisting of Degrees and Minutes, take the given Number to the bigger Latitude, and to that add the proportional Part of the Difference found against the bigger Latitude, the Sum is the Given Number required. One Example will make it plain.

Suppose I desire to know the Given Number for Lat. 45° 40', the Number for 46 (the bigger Latitude) is 6946, and the Difference 124; one Third of which viz. 41 nearest, added to the Number 6946, the Sum 6987 is the Number required.

But if you want the Given Number to any odd Minutes, which is not an even Part of a Degree, as 45° 41' or a Third, &c. you may find it by Proportion, as you would be very exact, or if your Question be in great Numbers, and the Proportion is, As 60 to the whole Difference, so the Minutes, which the given Latitude wants of the bigger Latitude, to the Given Number to be added to the Given Number of the bigger Latitude.

I desire to know the Given Number for Lat. 43° 24'. The Latitude 43° 24' wants 36 Min. of 44° therefore, as 60 to the Difference 120, so 36 to 7193, which added to 7193, the given Number for the bigger Latitude, the Sum 7265 is the Number for 43° 24' required,

Note, If you use all the four Figures of the Given Number, the Difference is as it is exprest in the Table; but if you cut off one Figure or two, &c. the Given Number to the right Hand, you must

Art. 3. *Parallel Sailing Arithmetical.*

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cut off as many from the Difference, and the Remainder is the Difference; only if the last Figure of the Difference be 8 or 9, you may add one to the third Figure, as in other Cases before-mentioned; the Reason is evident to them that understand Decimals.

Example. I desire to know the given Number for Lat. $69^{\circ} 45'$. I cut off one Figure to the right hand of each collateral Number, *viz.* Lat. 69, and Lat. 70, and then the Numbers are 358 and 342; and seeing I cut off a Figure from the Number, I must also cut one from the Difference, and then the Difference is 16, which used according to the foregoing Rules, the given Number for Lat. $69^{\circ} 45'$, will be found to be 358, and so in others.

CASE I. *Two Ships or Places in one Parallel, their Latitude and Distance given, to find their Difference of Longitude.*

The RULE.

Add so many Cyphers to the Distance as you think use Figures in the Given Number, and divide by the Given Number for the Latitude of the Parallel, Quotient is the Difference of Longitude.

Question. Two Ships in Lat. of $50^{\circ} 00'$, distant 6428 Miles, I demand their Difference of Longitude.

The Given Number for Lat. 50 is 6428, but if I cut off one Figure to the right hand, it will be 642; but because the last Figure, *viz.* that to the right hand, which I cut off, is 8, I add one to the third, and then it will be 643; and because I use three Figures of the Given Number, I add three Cyphers to the Distance, and then divide one by the other, according to the aforesaid Rule, and the Work will stand thus:

643) 76000(118 The Diff. of Long. 118 M. or 1°

$$\begin{array}{r}
 1170 \\
 \underline{5270} \\
 126
 \end{array}$$

Or if I cut off two Figures, the rest to work with will be 64, and then I add but two Cyphers to the Distance (because I use but two Figures of the given Number) and the Work stands thus :

64) 7600(118 The same with the foregoing Operation.

$$\begin{array}{r}
 120 \\
 \underline{560} \\
 48
 \end{array}$$

CASE II. *Two Places in one Parallel, their Latitude and Difference of Longitude given, to find their Distance.*

The RULE.

This is only the former Case inverted ; for having found the Given Number for the Latitude, multiply the Difference of Longitude by it, and from the Product cut off as many Figures as you multiply by, the rest is the Distance requir'd ; and those cut off as a Decimal Fraction to be understood as in the Rule laid down at the Beginning of *Plain Sailing Arithmetical*.

Question. Two Places in Lat. 50, their Difference of Longitude 118, I demand their Distance.

$$\begin{array}{r}
 643 \\
 \underline{118} \\
 5144 \\
 643 \\
 \underline{643} \\
 751874
 \end{array}$$

The Distance 75 $\frac{874}{1000}$, or rather 75

CAS

Case III. *Two Places, their Distance and Difference of Longitude given, to find the Latitude they are in.*

The RULE.

Add three or four Cyphers to the Distance, and divide that Sum, by the Diff. of Longitude, the Quotient is the given Number for the Latitude required.

Question. A Ship sails due West 2700 Miles, and finds her Difference of Longitude to be 4200 Min. Demand what Latitude the Ship is in.

$$\begin{array}{r} 4200 \overline{) 2700000} 642 \\ \underline{180} \\ 12000 \\ \underline{3600} \end{array}$$

By adding three Cyphers to the Distance, and working as before directed, you find the Quotient 642; if you add four Cyphers, it will bring out four Figures in the Quotient, viz. 6428, which found in the Table, you find it against Latitude 50, which is Latitude of the Parallel required.

Case IV. *Two Ships sailing directly North or South, their Distance in one Parallel given, to find their Distance in the other Parallel.*

The RULE.

Find the given Numbers for each Latitude, and say the Rule of Three: As the given Number for the 1st Lat. to the given Number for the second Lat. so the Distance in the first Latitude to the Distance in the second Latitude.

Que-

Question. Suppose two Ships in Lat. 50, distant 200 Miles, sail both directly North into Lat. 73. I demand their Distance in that Parallel.

Here we shall use but the two first Figures of the given Numbers, because the third Figure in the given Number is but small, viz. 2: And then, by the following Rule,

As 64 to 29, so 200 to the Distance in Lat. 73

$$\begin{array}{r}
 29 \\
 200 \\
 \hline
 5800
 \end{array}
 \qquad
 \begin{array}{r}
 64)5800(90 \\
 \hline
 40
 \end{array}$$

Their Distance in Lat. 73, is $90\frac{2}{3}$, or (if you would avoid Fractions) 91 Miles.

CASE V. Two Ships in one Parallel with their Distance in that Parallel given, and sailing both directly North or South, with their Distance in the Parallel sail'd to, given, to find the Latitude come to.

The RULE.

This is only the former Proportion (in Case I) inverted, viz. As Distance in one Latitude, to Distance in the other Latitude; so the given Number for one Latitude to the given Number for the other Latitude.

Question. Two Ships in Lat. 50, distant 200 Miles, sail both directly North, till they are but 91 Miles distant, I demand the Latitude come to.

As 200 to 91, so 64 to the given Number for the Latitude come to.

$$\begin{array}{r}
 91 \\
 64 \\
 \hline
 364 \\
 546 \\
 \hline
 5824
 \end{array}
 \qquad
 \begin{array}{r}
 200)5824(29 \\
 \underline{182} \\
 24
 \end{array}$$

The Quotient 29 is the two first Figures of the given Number for the Lat. come to, *viz.* Lat. $73^{\circ} 00'$.

SECT. IV.

Middle Latitude Sailing Arithmetical.

IN working the several Cases and Questions of *Middle Latitude Sailing*, we shall have Occasion to make Use of both the Tables of Given Numbers; for all Cases or Varieties, where the *Course*, *Distance*, *Difference of Latitude*, and *Departure*, are Terms, either given or Required, the Operation is performed by the first Table, as in *Plain Sailing*; but when *Difference of Longitude* is a Term in the Question, (whether Given or Required) the second Table is of Use, as will appear by the following Examples.

CASE I. *One Latitude, Course and Distance, given, to find the other Latitude, Departure, and Difference of Longitude.*

The RULE.

By *Course and Distance* find *Difference of Latitude* and *Departure*, (and consequently the other *Latitude*, as

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as in *Case I*, of *Plain Sailing Arithmetical*; and then the Difference of Longitude, it is found by the *Second Table*, thus: Find the Given Number for the *Middle Latitude*, of which you may use two, three, or four Figures, according to the Rules laid down at the Beginning of *Plain Sailing*, and also at the Beginning of *Parallel Sailing Arithmetical*; then to the Departure add so many Cyphers to the Right hand, as you intend to use Figures in the Given Number; that Sum divided by the Given Number, the Quotient is the Longitude required.

Question. A Ship in Lat. $50^{\circ} 00'$ North, sails W. by N. 987 Miles, I demand the Latitude come to, with Departure, and Difference of Longitude.

For the Difference of Latitude and Departure the first *Case of Plain Sailing Arithmetical*,

Diff. of Latitude.

For Departure.

$$\begin{array}{r} 987 \\ \underline{83} \\ 2961 \\ 7896 \\ \hline 81921 \end{array}$$

$$\begin{array}{r} 987 \\ \underline{556} \\ 5922 \\ 4935 \\ \hline 4935 \\ \hline 5481772 \end{array}$$

Although the three first Figures of the Given Number to find the Departure for that Course be 555, the last Figure being 6, I cut it off, and add one to the third Figure, and call it 556, as in the Operation above, and so the Difference of Latitude is 819, or rather 820, and the Departure 549, allowing one for the Fraction.

Then for the Difference of Longitude.

The Diff. of Latitude being 820 Min. or $13^{\circ} 40'$ the Latitude come to is $63^{\circ} 40'$, and consequently

Case 4. Middle Lat. Sailing Arithmetical. 141

Middle Latitude is $56^{\circ} 50'$, the Given Number for Latitude (found by the Rules laid down in the beginning of *Parallel Sailing*) is 5470 ; but the last figure being a Cypher, I cut it off, and work with the rest, as in the Rule above, and the Operation runs thus:

$$\begin{array}{r} 549000(1003 \quad \text{The Difference of Longitude is} \\ \underline{..2000} \quad 1003 \text{ Min. or } 16^{\circ} 43' \text{ West.} \\ 359 \end{array}$$

CASE II. Both Latitudes and Course given, to find the Departure, and Difference of Longitude.

The RULE.

Find the Distance and Departure, as in Case the second of *Plain Sailing Arithmetical*, and then find the Difference of Longitude, as in the first Case of *Middle Latitude Sailing Arithmetical*.

Note, In *Middle Latitude Sailing Arithmetical*, this way of finding the Longitude answers in all the Cases thereof, and therefore I shall not need to mention it the rest of the Cases.

Question. A Ship takes her Departure from *St. Abbs* and in Latitude $56^{\circ} 25'$ North, and sails N. N. E. she finds herself to be by Observation in Latitude $30'$ North; I demand the Distance sail'd, with Departure, and Difference of Longitude.

The Difference of Latitude is $12^{\circ} 05'$, or 725 Min.

For the Distance.

$$\begin{array}{r} 924)725000(784 \\ \underline{.7820} \\ 4280 \\ \underline{584} \end{array}$$

For the Departure.

$$\begin{array}{r} 785 \\ \underline{383} \\ 2355 \\ 6280 \\ \underline{2355} \\ 400655 \end{array}$$

The

The Middle Latitude, $62^{\circ} 28'$.

The Given Number for $62^{\circ} 28'$ is 4622.

Then for Difference of Longitude.

$$\begin{array}{r} 462 \overline{) 301000} (651 \\ \underline{2380} \\ \cdot \cdot 700 \\ \underline{238} \end{array}$$

The Diff. 785; the Departure 301; the Diff. Longitude $651 \frac{1}{2}$ Min. or $10^{\circ} 51'$ East.

CASE III. *Both Latitudes and Distance given find the Course, Departure, and Difference of Longitude.*

The RULE.

Find the Course and Departure, as in *Case IV. Plain Sailing Arithmetical*, and the Difference of Longitude, as in the other Cases hereof.

Question. A Ship in Lat. $55^{\circ} 00'$ sails between North and East 86 Miles, and then finds herself by Observation in Lat. $56^{\circ} 10'$, her Course, Departure, and Difference of Longitude, is required.

For the Departure by the square Root.

86	70	Square of the Distance	7396
86	70	Square of the Departure	4900
516	4900	Diff. of the Squares	2496
688			
7396			

2496(49
16
896
801
95

The Departure 50 nearest; because the Fraction is more than the Root by the general Rule in *Case V*, of *Plain Sailing Arithmetical*.

the Difference of Long.

For the Course.

Midd. Lat. is $55^{\circ} 35'$.
Given Numb. 5652.
5)50000(88
4800
280

86)70000(813
120
340
82

the Departure 50 ; the Course N. E. $\frac{1}{4}$ N. and the Difference of Longitude $88\frac{1}{2}$ fere.

SE IV. Both Latitudes and Departure given, to find the Course, Distance, and Difference of Longitude.

The RULE.

Find the Course and Distance by *Case VI* of *Plain Sailing Arithmetical* ; and Long. as in the other Cases. *Question.* A Ship in Lat. $55^{\circ} 00'$ North, sails bearing North and East into Lat. $56^{\circ} 10'$ North, her Departure 50 Min. or Miles, the Course, Distance, Difference of Longitude are required. The Difference of Latitude is 70 Miles.

For the Distance by the Square Root:

50	Sq. of Diff. Lat.	4900	7400(86
50	Square of Dep.	2500	64
2500	Sum of Squares	7400	166)1000
			996
			004

For

*For the Course.**For the Diff. of Long.*

86)70000(813

120

340

82

The Mid. Lat. 35°

The Given Num. 565

565)50000(

4800

280

The Distance 86; the Course N.E. $\frac{1}{2}$ N. the
of Longitude $88 \frac{1}{2}$ Min. or $1^{\circ} 28'$ East.

CASE V. Both Latitudes and Diff. of Long.
given, to find Course, Distance and Departure.

The RULE.

In all Cases where the Difference of Longitude
given; and Departure required, the Operation is
the Inverse of that for finding Difference of Longitude
when Departure is given; for if the Departure
with Cyphers added to the right hand, and divide
the given Number, for the Middle Latitude, produce
the Difference of Longitude; then the Difference of
Longitude, multiplied by the Given Number for
Middle Latitude, must needs produce the Departure
with Figures to be cut off; because any Quotient
multiplied by the Divisor produceth the Dividend; therefore,
to find the Departure in this Case, multiply the
Difference of Longitude by the Given Number for
Middle Latitude, and from the Product cut off as
many Figures to the right hand as you multiply by,
the rest is the Departure; thus having Difference of
Latitude and Departure, find the Course and Distance
as in Case VI. of Plain Sailing Arithmetical.

Q. 4. *Middle Lat. Sailing Arithmetical.* 145

Question. I demand the Course, Distance and Departure, between two Places, one in Lat. $56^{\circ} 15' N.$ the other in Lat. $58^{\circ} 35' N.$ their Difference of Longitude, 150 Min. or $2^{\circ} 30'.$

For the Departure.

The Middle Latitude being $57^{\circ} 25'.$ and the Given Number 5384,

$$\begin{array}{r} 5384 \\ 150 \\ \hline 269200 \\ 5384 \\ \hline 807600 \end{array}$$

For the Course. For the Distance by the Square Root.

140000 (869	140	81	S. of D. Lat. 19600
. 1120	140	81	Sq. of Dep. 6561
1540	<u> </u>	<u> </u>	<u> </u>
	5600	81	Sum of Sq. 26161
. . 91	140	648	. . .
	<u> </u>	<u> </u>	26161 (161
	19600	6561	1
		<u> </u>	
		26) 161	
		156	
		<u> </u>	
		5) 561	
		321	
		<u> </u>	
		240	

The Distance is 161 ; the Departure $80\frac{76}{100}$, or (to Fractions) 81 ; the Course $2\frac{3}{4}$ Points to the Eastward or Westward of the North or South, according to the Denomination of the Longitude, whether East or West.

L These

These being the most useful Cases, I shall (*as Middle Latitude Sailing Trigonometrical*) set down the Data and *Quæstæ* of the rest, with Rules for working them, and leave the Operation for the Learner's Practice.

CASE VI. *One Latitude, Course, and Departure given, to find the other Latitude, Distance, and Difference of Longitude.*

The RULE.

Find the Distance and Difference of one Lat. (consequently the other Latitude) by *Case III* of *Sailing Arithmetical*, and Difference of Longitude in the other Cases.

CASE VII. *One Latitude, Distance, and Departure given, to find the rest.*

The RULE.

Find the Course and Difference of Latitude *Case V* of *Plain Sailing Arithmetical*, and Difference of Longitude as before.

CASE VIII. *Course, Departure, and Difference of Longitude given, to find both Latitudes and Distance.*

The RULE.

Find Distance and Difference of Latitude by *Case III* of *Plain Sailing Arithmetical*; then divide the Departure (with Cyphers added on the right Hand) by the Difference of Longitude, the Quotient is the *Number* for the Middle Latitude, consisting as many Figures as you added Cyphers; and the Middle Latitude, and Difference of Latitude, thus found, the other Latitude is easily found; by

ect. 4. *Middle Lat. Sailing Arithmetical.* 147

use Departure and Difference of Longitude given, find Middle Latitude, (and consequently both Latitudes) is a Variety that we have not had an Example in, I shall instance in one Question for the Reader's Practice.

Question. A Ship sails N. N. E. till her Departure 301, and Difference of Longitude 651: I demand the Latitudes and Distance.

For the Distance. For Diff. Lat. by the square Root.

$$\begin{array}{r}
 383 \overline{) 301000} (785 \\
 \underline{329} \\
 2260 \\
 \underline{2260} \\
 345
 \end{array}
 \qquad
 \begin{array}{r}
 785 \\
 785 \\
 \underline{1570} \\
 3925 \\
 \underline{3925} \\
 6280 \\
 \underline{6280} \\
 5495 \\
 \underline{5495} \\
 616225
 \end{array}
 \qquad
 \begin{array}{r}
 301 \\
 301 \\
 \underline{602} \\
 301 \\
 \underline{301} \\
 9030 \\
 \underline{9030} \\
 90601
 \end{array}$$

$$\begin{array}{r}
 \text{Square of the Distance} \quad \text{---} \quad 616225 \\
 \text{Square of the Departure} \quad \text{---} \quad 90601 \\
 \text{Diff. of the Squares} \quad \text{---} \quad 525624
 \end{array}$$

For the Middle Latitude. 525624(724

$$\begin{array}{r}
 651 \overline{) 301000} (462 \\
 \underline{4060} \\
 1540 \\
 \underline{1540} \\
 238
 \end{array}
 \qquad
 \begin{array}{r}
 49 \\
 142 \overline{) 356} \\
 \underline{284} \\
 1445 \overline{) 7224} \\
 \underline{5780} \\
 1444
 \end{array}$$

The Number 462 is the three first Figures of the given Number for the Middle Latitude, which answers to Lat. $62^{\circ} 28'$; then half the Difference of Longitude added to, and subtracted from the Middle Latitude, gives the two Latitudes, $56^{\circ} 25'$, and $68^{\circ} 30'$, the Distance is 785.

Note, Altho' the Diff. of Lat. comes out but 72, yet the Fraction is so great, that if the Number had been but one Unit more, the Root had been 725.

CASE IX. *Middle Latitude, Course; and Distance given, to find both Latitudes, Departure, and Difference of Longitude.*

The RULE.

By Course and Distance find Difference of Latitude and Departure, by *Case I of Plain Sailing Arithmetical*, and then find Difference of Longitude, as in other Cases.

CASE X. *Course, Distance, and Difference of Longitude given, to find both Latitudes and Departure.*

The RULE.

Find Difference of Lat. and Departure by *Case I of Plain Sailing Arithmetical*, and then find Middle Latitude, and consequently both Latitudes, by *Case V* hereof.

CASE XI. *Course, Difference of Latitude, and Difference of Longitude given, to find both Latitudes, Distance and Departure.*

The RULE.

Find the Distance and Departure by *Case II of Plain Sailing Arithmetical*, and then find Middle Latitude, and thereby both Latitudes, by *Case V* hereof.

CASE XII. *Middle Latitude, Course, and Difference of Longitude given, to find both Latitudes, Distance and Departure.*

The RULE.

For the Departure multiply the Difference of Longitude by the Given Number for the Middle Latitude, and from the Product cut off as many Figures to the right Hand as you multiply by, and the rest is the Departure, and thus having the Course and Departure, you may find the Distance and Difference of Latitude, and (by the Help of Middle Latitude) both Latitudes, by *Case III of Plain Sailing Arithmetical.*

CASE XIII. *One Latitude, Departure, and Difference of Longitude given, to find the other Latitude, Course and Distance.*

The RULE.

Find the Middle Latitude by *Case VIII* hereof, and having one Latitude, and Difference of Latitude, the other Latitude is easily found; and thus having the Latitudes and Departure, find Course and Distance by *Case VI of Plain Sailing Arithmetical.*

And thus I have gone thro' the Thirteen Cases of *Middle Latitude Sailing Arithmetical*, where in the first Cases, in which there are Questions proposed and sought, I have set down the very same Questions that are in *Middle Latitude Sailing Trigonometrical*, that the Reader may see the exact Harmony between *Trigonometrical* and *Arithmetical Operations*, and frequently, may be convinced of the Truth and Plainness of this Way of working, so far as *Middle Latitude Sailing* is to be depended upon; and although *Middle Latitude Sailing* deviates somewhat from *Meridian* especially at a great Distance from the Equinoctial, or where the Question is proposed in great Numbers, yet it may be of great Use in keeping a Reckoning;

ning ; because, in a single Day's Work, (which seldom exceeds 30 or 40 Leagues) the Difference is scarcely discernable ; and always observe, that if through Haste you cannot take Time to reckon the Middle Latitude exactly to a Minute, take rather a Latitude too great than too little for Middle Latitude, and that will lessen the Error, as I hinted in *Middle Latitude Sailing Trigonometrical, Case I.*

CHAP. V.

Instrumental Navigation.

SECT. I.

Plain Sailing Instrumental.

MY Intent in this Section of *Instrumental Navigation*, is not to write a large Treatise of the Instruments that are useful in Navigation ; for that would make too large a Part in this small Treatise ; but I shall here shew, how all the Propositions in *Plain Sailing, Mercator, &c.* (which are in other Parts of this Treatise solved Geometrically, Trigonometrically, Arithmetically, &c.) may be solved Instrumentally, viz. by Scale and Compasses ; and I shall confine my self only to the Use of *Gunter's Scale*, it being an Instrument so common and expeditious in Instrumental Operation, that few that are inclined to improve themselves in the Knowledge of Navigation

on, go to Sea without them. In order to the right understanding of which, it is necessary, first, to give Description of that Part of the Scale which serves for our present Purpose, and then proceed to the Use of it.

The first Line next the Top, commonly marked *R.* is the Sine Rumbs, and is numbred 1, 2, 3, 4, 5, 6, 7, and ends at the Brass Nail with 8, which is Radius, because 8 Rumbs, or Points of the Compass, make a Quarter of the whole Circle, and therefore equal 90 Degrees.

The next Line marked *T. R.* is the Tangent Rumbs, and this Line is numbred 1, 2, 3, and then at the Brass Nail 4, the Tangent of 4 Points, or 45 Degrees, being equal to Radius, and then proceeds back towards the left Hand with 5, 6, 7; the Tangent of 8 Points, or 90 Degrees, being infinite.

These Sine Rumbs and Tangent Rumbs, are only useful in Navigation. The Sine Rumb, or Tangent Rumb, being only the Sine or Tangent of the Degrees and Minutes answering to those Rumbs: Thus, because 1 Point of the Compass contains $11^{\circ} 15'$, therefore the Sine of 1 Point is equal to the Sine of $11^{\circ} 15'$, &c. Also 3 Points are $33^{\circ} 45'$; therefore the Sine of 3 Points, in the Sine Rumbs is exactly against Sine of $33^{\circ} 45'$ in the Sines, and the Tangent of 3 Points is right against the Tangent of $33^{\circ} 45'$, &c.

The next Line being the third in order, marked *N.* is the Line of Numbers, which is numbred on the left Hand with 1, 2, 3, 4, 5, 6, 7, 8, 9; and on the right Hand with 10, 20, 30, 40, 50, 60, 70, 80, 90, 100. The Divisions at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The Divisions at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. being the greatest, and growing less towards 9, 10. These Divisions being divided each into 10 Parts, and every one of these again subdivided (where it will permit) into 10 Parts, and are thus read: You call 1 at the left hand 1, then the next 2 is 2, 3, 4, 5, &c. to 9, and the 1 on the Middle is 10, and the next 2, 3, 4, &c. is 20, 30, 40, &c. and

and the 10 at the right hand, is 100, and thus when 1 in the Middle is 10, and the 2 is 20, &c. then every one of the 10 lesser Divisions between 1 and 2 is 10. Thus 1 being 10, the next smaller Division is 11, the next 12, where there is commonly a Brass Nail and so on, to 13, 14, 15, &c. till you come at 2 for 20, and 3 for 30, and so in the rest.

But if you make 1 at the left Hand 10, then 10 in the Middle is 100, and 10 at the right Hand is 1000, and then every one of the lesser Divisions, which before was reckoned 1, is now reckoned 10, &c. Thus the 1 at the Middle being 100, the next small Division (which before was called 11) is now 110, the next where the Brass Nail is, 120, &c. and every one of the smallest Subdivisions is called 10. Thus suppose I would find 125, on the Scale I call in the middle, (or at the left hand) 100; and counting 2 of the small Divisions further (which is just to the Brass Nail) and then 5 of the smallest Subdivisions there I hold my Compasses, it being the Number required; a little Practice will make it easy.

The next Line is the Sines mark'd at the left Hand [*Sines*], and numbred from the left hand, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90; the longer Subdivisions between 10 and 20 and between 20 and 30, &c. being each 1 Degree, but the Degrees under 20 are subdivided into 6 Parts, each Part being 10 Minutes; and where the Degrees are divided into 4 Parts, each Part is 15 Minutes. Thus suppose I seek the Sine of $23^{\circ} 30'$; first I find 23; and then count 3 of the bigger Subdivisions, which are 15 Minutes; and then 2 of the smallest Subdivisions for 30 Minutes (because the Degree is divided into 4 Parts) and there is the Point representing the Sine of $23^{\circ} 30'$, where there is commonly a Brass Nail, as at 12 on the Line of Numbers.

The next Line is versed Sines marked [*V. Sines*], which there is seldom Use made in Navigation.

The next is Tangents, mark'd at the right hand
[ang.] they proceed from the left hand to the right,
from 1 to 45, and then back to the left hand towards
the Subdivisions are understood in all Respects, as
of the Line of Sines, and therefore need be no
other explain'd.

By this Scale, and a Pair of Compasses, may be per-
form'd all the Propositions in *Trigonometry* and *Navi-*
gation, in all their Parts. As they are solved elsewhere in
this Treatise by Geometrical Construction, and by Al-
gebraical Calculation, so here I shall shew how they
may be solved by Instrumental Operation; and here,
what ever the Question be, the Proportion for an-
swering it is the same as in *Trigonometry*, by Logarithms,
Sines and Tangents; only whereas in Natural Num-
bers, the Operation is perform'd by Multiplication
and Division, (when three Numbers are given to find
the fourth) and in Logarithms it is done by Addition
and Subtraction; so here it is performed by taking in
our Compasses the Distance upon the Scale, between
the first and second Given Terms, and the same Extent
shall reach from the third Given Term to the fourth
Term required; but because, if the second Term
have the same Proportion to the first that the fourth
Term hath to the third, then the third will have the same
Proportion to the first, that the fourth hath to the se-
cond, by *Euclid. Lib. 5. Prop. 16.* and therefore, when
the first and third Term are both of one Denomina-
tion, viz. both Sines, or both Tangents, or both
Numbers, as it happens in most Questions in *Navi-*
gation, and where the second and fourth are also of
the Denomination, I would rather advise to extend
from the first to the third, and by that means you keep
along one Line, whether Sines, Tangents, or Num-
bers; and then the Proportion and Answers will come
out the same, as by Trigonometrical Calculation.

And because the Proportions in this manner of
working are the same as in the Logarithmical Operati-
ons,

ions, I shall not be at the Pains of Running over the particular Cases of *Plain Sailing*, and *Mercator*, as in the *Geometrical* and *Trigonometrical* Parts here, but shall only instance in some few Questions, thereby shew the Learner how all the rest may be deduced from the Proportions elsewhere laid down in the *Trigonometrical* Part.

Example in Plain Sailing.

CASE I. *Course and Distance given, to find the Difference of Latitude and Departure.*

A Ship sails N. W. by N. 123 Miles, I demand her Diff. of Latitude and Departure.

First, for the Diff. of Latitude.

You may observe in the *Trigonometrical* Part, that the Proportion is, As Radius to the Distance, so Sine Complement of the Course to Difference of Latitude; therefore here the Course being N. W. by N. that is three Points from the Meridian, its Complement is five Points; therefore extend on the Sine Rumbs from Radius (the Brass Nail at the End) to five Points, the same Extent will reach on the Line of Numbers from 123 to 102, the Diff. of Latitude required.

Then for the Departure.

The Proportion in *Trigonometry* is, As Radius to Distance, so Sine of the Course to Departure; therefore extend from Radius to 3, on the Sine Rumbs, the same Extent will reach from the Distance 123 (on the Line of Numbers) to 68, the Departure required.

Note, The same may be performed on the Line of Sines; for if you extend from Radius to Sine of 33° 45'

Course reckoned in Degrees and Minutes, along $11^{\circ} 15'$ to a Point) the same Extent will reach the Line of Numbers from the Distance 123 to the Parture 68, as before; and for Difference of Latitude, extend from Radius to Sine Complement of the Course, $56^{\circ} 15'$, the same Extent will reach from the Distance 123 to the Difference of Latitude 102, and others.

Thus in *Plain Sailing*, *Case II*, where Course and Difference of Latitude is given, to find the Distance and Departure, you see in the *Trigonometrical Part*, the Proportion for finding the Distance is, As Sine Complement of the Course to the Difference of Latitude, so Radius to the Distance; therefore extend from Sine Complement of the Course to Radius, the same Extent will reach from the Difference of Latitude to the Distance.

Example. A Ship sails S. W. by S. till her Difference of Latitude be 174 Miles, I demand her Distance and Departure.

First, for the Distance.

Extend from 5 on the Sine Rumbs (or from $56^{\circ} 15'$ on the Sines) the Complement of the Course; to Radius: The same Extent will reach from the Difference of Latitude 174, to the Distance 209; then for the Departure, the Proportion is; As Sine Complement of the Course, to Difference of Latitude, so Sine of the Course to the Departure: Therefore extend from Sine Complement of the Course 5 on the Sine Rumbs, (or $56^{\circ} 15'$ on the Sines) to the Sine of the Course; the Rumbs, (or $33^{\circ} 45'$ on the Sines) the same Extent will reach on the Line of Numbers from the Difference of Latitude 174, to the Departure 116.

In

In the like manner are all the Cases in *Plain Sailing* and *Mercator* performed on the Scale, if you do know the Proportions, (which you have at large the *Trigonometrical* Part) and therefore I need not large any further upon it; only this is to be observed that you must mind always to extend your Compass the same Way (whether backwards or forwards) as the last Extent that you do at the first; that is, if your Extent from the first Number to the second be from the left hand towards the right, then your fixed Point being placed at the third Number, the moveable Point must be extended towards the right hand also, and the contrary, unless in case you have to extend from Tangent above 45, because they increase from the right hand towards the left (as hath been said before) of which you have sometimes Occasion to make Use in *Case VI* of *Plain Sailing*; as for Example.

A Ship sails between the South and West till the Difference of Latitude be 80, and her Departure 95. I demand her Course and Distance.

The Proportion being, As Difference of Latitude to Radius, so Departure to Tangent of the Course, therefore extend from Difference of Latitude 80 to Radius, and the Departure 95, (which is towards the right hand because increasing, viz. 95 is more than 80;) the same Extent will reach from Radius to the Tangent of the Course, 50; and although Radius is at the beginning of the Line, so that you cannot extend any further towards the right hand, yet in your extending towards the left hand, you must count the Degree that the Compass Point falls upon, on those Degrees which increase above 45 towards the left hand; thus in this Case, you find the moveable Point of the Compass upon a Stroke marked 40/50, viz. it is either the Tangent of 40 or of 50; but the Extent from 80 to 95 being towards the right hand increasing, and your fixed Point being placed in the second Extent at Radius, viz. Tangent of 45, you must account the second

also increasing, and the Tangent that is above
viz. 50, is the Answer to your Question; and
(with the Help of *Plain Sailing Trigonometrical* for
finding the Proportions till you have them by heart)
be sufficient for *Plain Sailing Instrumental*.

SECT. II.

Mercator's Sailing Instrumental.

Mercator's Sailing, as well as in *Plain Sailing* the
Proportions are the same as in the *Trigonometrical*
and may be learn'd in *Mercator's Sailing Trigonometrical*;
but because my Design is to shew how all
Cases hereof may be solved by Scale and Com-
passes, without Tables, I shall first shew how the Me-
ridional Difference of Latitude may be found by the
Scale and Compasses, both Latitudes being first given
found.

There is upon the Scale 2 other Lines, besides what
I have yet spoke of, which are next the lower Edge
of the Scale; the first of them next the Tangent Line
is the Meridian Line, marked [*Merid.*] and the next
lowest is a Line of equal Parts, marked [*Eq. P.*]
These are of Use for Graduating a *Mercator's Chart*, (of
which more elsewhere in this Book) and also for find-
ing the Meridional Difference of Latitude. The e-
qual Parts are Degrees of the Equinoctial, and every
Division, or Degree contains 60 Miles, or Minutes;
hence every 10 Degrees mark'd 10, 20, 30, &c.
contains 600 Miles; but the Degrees of Latitude grow
larger towards the Poles, in a *Mercator's Chart* for
keeping the same Proportion to the Degrees of Longi-
tude, that they do upon the Globe, every Degree,
nearer the Pole, contains so many more Meridional
Miles,

Miles, according as the Degrees of Latitude upon Meridional Line grow larger, as the Latitude increases; hence, to find the Meridional Difference of Latitude, when the two Latitudes are given or for extend the Compasses between the two Given Latitudes on the Meridional Line, which done, apply same Extent to the equal Parts, and accounting every 10 Degrees 600 Miles, every Degree 60, and each half Degree 30 Miles, &c. you have the Meridional Difference of Latitude between the two Places, so may find what is required, and answer your Question *Instrumentally*, as well as *Trigonometrically*, if be carefull in the Operation.

Example in Mercator's Sailing, Case I.

A Ship in Latitude $50^{\circ} 00'$ N. sails N.W. by N. 10 Miles, I demand the Latitude come to, and Difference of Longitude.

According to the former Directions, extend the Radius to Sine Complement of the Course, (*viz.* the Sine Rumbs, or $56^{\circ} 15'$ on the Sines) the same Extent will reach from the Distance 987 to Difference of Latitude 820 Miles or Minutes, or $13^{\circ} 40'$, which added to the Latitude sail'd from, finds the Latitude come to $63^{\circ} 40'$; then to find the Meridional Difference of Latitude, extend the Compasses on the Meridian Line from $50^{\circ} 0'$ to $63^{\circ} 40'$, that Extent applied to the equal Parts, accounting (as before directed) every 10 Degrees for 600, and each Degree for 60 Miles or Minutes, will be found to be 1180 the Meridional Difference of Latitude. Then to find the Difference of Longitude, proceed according to the Proportion in *Mercator's Sailing Trigonometrical*, *Case 1.* *viz.* Extend from Radius to the Tangent of the Course, (*viz.* 3 on the Tangent Rumbs, or 33° on the Tangents, the same Extent will reach

Pl. 2. *Mercator's Sailing Instrumental.* 159

Meridional Difference of Latitude 1522, to the Difference of Longitude 1017, and so in others.

In *Case II*, where both Latitudes and Course is given, the Distance is found as in *Case II* of *Plain Sailing Instrumental*, and the Difference of Longitude as in *Case I* hereof, which is so easy, that it needs no Example.

CASE III. *One Latitude, Course, and Difference of Longitude given, to find the other Latitude and Distance.*

A Ship in Lat. 50 North, sails N. N. W. till her Difference of Longitude be 7 Degrees, or 420 Min. Demand as above.

Extend from the Tangent of the Course, two Points Radius, the same Extent will reach from 420, the Difference of Longitude, to 1014, the Meridional Difference of Latitude.

Take the Meridional Difference of Latitude 1014 in the Scale of equal Parts, then with that Extent, one Foot in Lat. 50, on the Meridian Line, the Arc will reach to $59^{\circ} 40'$, the Latitude come to: then for the Distance extend from Sine Complement the Course (6 on the Sine Rumbs, or by 30 on the Arcs) to Radius, the same Extent will reach from the Meridional Difference of Latitude 580 to 628, the Distance required.

SECT.

S E C T. III.

Parallel and Middle Latitude Sailing Instrument

THE Proportions for solving all the rest of Cases, both in *Mercator* and *Parallel Sailing*, also in *Middle Latitude*, may be so easily deduced from the Proportions laid down in the *Trigonometrical* Part that I need say no more about them; only in the Instrumental Operation, where a Tangent is required the End of the Compass will sometimes fall beyond the End of the Line; as suppose the Proportion was As Tangent $21^{\circ} 30'$ to Tangent $37^{\circ} 20'$, so Tangent $42^{\circ} 40'$, to a Tangent required. And here, if you extend from the first Term $21^{\circ} 30'$, to Tangent $37^{\circ} 20'$, the same Extent will reach from $42^{\circ} 40'$, to beyond the End of the Scale; but to remedy this, extend from Tangent $21^{\circ} 30'$, to Tangent $37^{\circ} 20'$, then with the same Extent, and one Foot in Tangent 45, extend the other back towards the left hand, and where ever it lights, keep it fix'd, and close the other to the first Term, viz. Tangent $42^{\circ} 40'$, then with this Extent and one Foot in Tangent of 45, the other will fall on Tangent $60^{\circ} 45'$, the Tangent requir'd.

As for *Traverse Sailing*, it being compounded of several Questions in *Plain Sailing*, I shall not need speak of it in this Place, supposing that by what is already laid down in this Section of *Instrumental Navigation*, the Learner will be able to make Application as Occasion requires, without any further Instruction.

CHAP. VI.

Navigation New Modell'd;

O R,

The Whole ART Perform'd

B Y A

New Method.

S E C T. I.

Rules and Grounds of the Method.

IN order to the right Understanding of this new Method of *Trigonometry*, I shall proceed, according to the usual Method, and shall, for the Help of Memory, lay down some fundamental Rules or Axioms, upon which the whole Operation depends, by which all the Cases in *Plain Trigonometry*, both Rect and Oblique, may be solved, without any Table, or Instrument, whatsoever. But before I come to the Axioms, I shall premise, that whenever one Side and an Angle is given, to find another Side, (which is the first and most useful Case in Navigation) we must first be a Number found, which I call the Natural Radius, not only because it is the Original, whence the Solutions are deduced, but also because being found, it produces the same Answer in

M

Natu-

162 Rules and Grounds of the Method.

Natural Numbers, that the Radius, or Sine of 90, reduces in a Sinical Proportion, and this Natural Radius thus found.

METHOD the First.

Take the Angle whose opposite Side is either or sought, and divide four times the Square of its Complement to 90 Degrees, by 300 added to three times the said Complement, and then the Quotient is to the said Angle is the Natural Radius required: this Rule is universally true in all Angles from 0

METHOD the Second.

But because in Angles under 45, the Complements are above 45, and their Squares amount to greater Numbers than the Squares of the Complements of Angles above 45; therefore, to render the Rule as easy, and the Contrivance as useful as possible, shall shew another Way to find the Natural Radius in all Angles under 45, and the Rule is;

Divide three Times the Square of the Angle (whose opposite Side is given or sought) by 1000, the Quotient added to 57:3, (that is $57\frac{3}{10}$) the Sum is the Natural Radius required.

This being premised, the Rules are these.

RULE the First. In Right-angled Triangles

An Angle and a Side given, to find another Side

The Natural Radius bears always the same Proportion to the Hypotenuse that the Angle (by which the Natural Radius was found) bears to its opposite Side.

Therefore if the Angles and Hypotenuse be given, it is; As Natural Radius, to Hypotenuse; So Angle to its opposite Side. But if the Angle and Leg be given, then it is, As the Angle to its opposite Side; So Natural Radius to the Hypotenuse.

RULE the Second. In Right-angled Triangles.

Two Sides given, to find a Third.

The Hypotenuse is equal in Power to the two Legs :
 is, the Square of the Hypotenuse is equal to the
 are of both Legs added together ; of which see
 in Plain Sailing Arithmetical.

RULE the Third. In Right-angled Triangles.

The Hypotenuse and a Leg given, to find the other Leg.

Multiply the Sum of the Hypotenuse, and given
 by their Difference : The Square Root of the
 is the other Leg required.

RULE the Fourth. In Right-angled Triangles.

Three Sides given, to find an Angle.

Take half the longer Leg to the Hypotenuse : Then,
 at Sum, to 86 : So the shorter Leg, to its oppo-
 site Angle.

RULE the Fifth. In Oblique Triangles.

*Sides given, to find where the Perpendicular must
 fall.*

Multiply the Sum of the two shortest Sides by their
 difference, and divide the Product by the third Side,
 is the greatest, and upon which the Perpendi-
 cle is to fall : The Quotient added to the greatest
 or subtracted from it, shall be double the greater
 or Segment, on each Side of the Perpendicular.

Another Way.

Take the Squares of the biggest and least Sides toge-
 ther, and from their Sum subtract the Square of the

middle-most ; Half the Remainder, divided by biggest Side, the Quotient is the lesser Segment which subtracted from the whole Base, leaves the greater Segment.

See another Way in *Axiom IV* of *Plain Trigonometry*.

S E C T II.

Plain Sailing by a New Method.

I Shall now proceed to some Examples in Right angled Triangles, as applied to *Plain Sailing*; here note, That to avoid Fractions, I shall propose given Angle always in whole Degrees, that being sufficiently exact in all Uses in Navigation; yea, a far more exact Way, than reckoning by Points, or Quarter Points; one Degree being a smaller Part of a great Circle than a Quarter Point of the Compass. And I shall make use of Degrees rather than Quarter Points, not only for its Exactness, also because it is a Method much in Use aboard of Men of War, to reckon the Course in Degrees, not in Points and Quarter Points.

CASE I. *Course and Distance given, to find the Difference of Latitude and Departure.*

Note, I shall in every Case hereof propose the Questions that are inserted in the second Example of each Case of *Plain Sailing Trigonometrical*.

A Ship sails South 25 Degrees, Easterly 96 Miles I demand as above.

2. Plain Sailing by a New Method. 165

The Operation at large.

Note, Where both Legs are required, chuse always the lesser first; because the Natural Radius is easily found; and then find the longer Leg by the Third.

For the Departure.

Then by Rule I.

Angle —————	25	As Natural Rad. 59.2.
multiplied by its self ———	25	to the Distance 96: So
	125	the lesser Angle 25, to its
	50	opposite Side the De-
re of the Angle ———	625	parture.
multiplied by ———	3	
Product —————	1875	96 592) 24000 (40½
divided by 1000 is 1.875		25 320
which add ———	57.3	480 320
is Natural Rad. 59.175		192 Nearest which
rather briefer ———	59.2	2400 40½ is the De-
which is exact enough.		parture req.

Then for the Difference of Latitude by Rule III.

hypotenuse or Distance 96.0			
Dep. in Decimals ———	40.5	7575 (87	The
Sum —————	136.5	64	Diff. of
Difference ———	55.5	167) 1175	Latit.
	6825	1169	
	6825	(6)	
	6825		
Product ———	7575.75		

Depart. is $40\frac{1}{2}$ (or in Decimals 40.5). The Diff. of Lat. 87.

CASE II. *Course and Difference of Latitude given to find the rest.*

A Ship sails North 28 Degrees West, her Difference of Latitude 120, her Distance and Departure required.

Here the Side opposite to the bigger Angle is given therefore we must make Use of *Method I*, to find the Natural Radius, because *Method II*, serves only to Degrees under 45.

38	38	414	5776	(13 ³ / ₄)	Because the Fraction is so great, I shall call the Quotient 14, which added to the bigger Angle 52, the Sum 66 is the Natural Radius.
<u>38</u>	<u>3</u>		<u>1636</u>		
304	114		394		
<u>174</u>	<u>300</u>				
1444	414				
<u>4</u>					
			5776		

Then by Rule I.

As 52, the greater Angle, to 120, its opposite Side So is Natural Radius, 66, to the Distance required

Then for Departure, by Rule III.

120	Distance 152 Diff. Lat. 120 Sum — 272 Difference 32 Product 8704	
<u>66</u>		
720		
<u>720</u>		
7920		
52		8704 (93 Departure)
<u>272</u>		
120		
<u>16</u>		

The Distance 152. The Departure 93.

CASE III. *Course and Departure given, to find Distance, and Difference of Latitude.*

A Ship sails North 19 Degrees Easterly, her Departure 72 Miles, I demand as above.

Here the shorter Leg is given; therefore I shall find Natural Radius by *Method II.*

Three times the Square of the given Angle 19
 681, this divided by 1000, which is done by 19
 taking off three Figures to the right Hand, 19
 Quotient is 1.081; which, because the 171
 and Figure in the Fraction is above 5, I 19
 add one to the first Figure, which is a Cypher, 361
 then call the Quotient 1.1, which added to 3
 the Sum 58.4 is the Natural Radius re-
 quired. 1.083

Then for the Distance, by *Rule I.*
 As the Angle 19, to its opposite Side 72: So Natu-
 ral Radius 58.4, to the Distance.

58.4	19)4204(221	The Di-
72	.40	stance re-
1168	.24	quired.
4088	5	
4204.8		

Then find *Difference of Latitude by Rule III.*

Distance	221	
Departure	72	43657(209
	293	4
Difference	149	40)03657
	2637	409 3264
	1172	(323)
	293	
	43657	

The Root 208, but the Fraction being so large, I rather call it 209, the Difference of Lat. required.

CASE IV. *Distance and Difference of Latitude given to find Course and Departure.*

A Ship sails between the North and East 117 Miles, her Difference of Latitude 103 Miles, I demand Course and Departure.

For the Departure, by Rule III.

Distance	117	
Diff. of Lat.	103	3080(55
Sum	220	25
Difference	14	105)580
	880	525
	220	(55)
Product	3080	The Departure 55.

Then for the Course, by Rule IV.

Hypotenuse or Distance	117
Half the longest Leg	51.5
Sum	168.5

As 168.5, to 86 : So shortest Leg, or Departure 55.5, to its opposite Angle, the Course.

55.5	168.5)4773.0(28	The Course 28.
86	1403.0	degrees, which is almost
3330	550	viz. 28 Degrees, 19
4440		minutes.
47730		

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SE V. Distance and Departure given, to find the rest.

Ship sails in the South West Quarter, 124 Miles, Departure 95 Miles, I demand her Course and Difference of Latitude.

For the Difference of Latitude, by Rule III.

Distance	124	
Departure	95	6351 (79
Sum	219	49
Difference	29	149) 1451
	1971	1341
	438	110
Product	6351	

The Square Root of 6351 is 79 or rather 80 (because the Remainder 110 is more than the Root) the Difference of Latitude required.

Then for the Course, by Rule IV.

Hypotenuse or Distance	124	124
Longest Leg, which here is Dep-95 its half	47.5	
Sum	171.5	

171.5, to 86 : So the shorter Leg (which here is Difference of Latitude) 80, to its opposite Angle the Complement of the Course.

86	171.5) 6880.0 (40 Degrees
80	. 020 0
6880	20.0

The Complement of the Course is 40 Degrees, and consequently the Course is 50 Degrees, from the South westerly, and the Difference of Latitude is 80 Miles

CASE

CASE VI *Difference of Latitude and Departure given, to find the Course and Distance.*

A Ship sails in the North West Quarter, till her Difference of Latitude be 220 Miles, and her Departure 108, I demand the rest.

For the Distance by Rule II.

220	108	Square of Diff. Lat. —	48400
220	108	Square of Departure —	11664
440	864	Sum of the Square —	60064
44	1080		4
48400	11664		44)200

Then for the Course, by Rule IV.

As 355, to 86 : So 108 to the Angle of the Course.

176
485)2464
2425
(39)

108	355)9288(26
86	2188
648	58
364	
9288	

The Distance is 245, and Course 26th Degrees, or 26th or N.N.W. from what more the $\frac{1}{2}$ West.

— SEC

SECT. III.

Oblique Triangles, by a New Method.

to solve all the Cases in Oblique Plain Triangles, by this New Method, without any Canon, Book, Instrument, &c.

IN the Solution of Oblique Triangles, by this New Method, it is necessary that they be first divided into two right-angled Triangles, by a Perpendicular fall, in which observe:

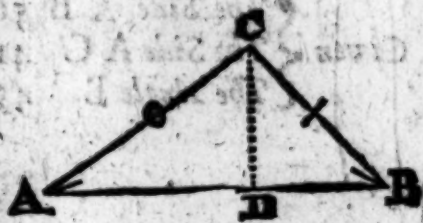
Let it fall from the End of a given Side, and opposite to the given Angle.

By this Means, the Perpendicular will sometimes within, and sometimes without; when it falls within, it falls upon some intermediate Part of the side, or longest Side; but when it falls without, it falls upon one of the shorter Sides continued; in either case, there is two right-angled Triangles produced, and then the Angles or Sides sought are found as if they were Parts of a right-angled Triangle.

CASE I.

Given $\left\{ \begin{array}{l} \text{The Angle at } A \ 30.0 \\ \text{The Angle at } B \ 45.0 \\ \text{The Side } BC \ 290 \end{array} \right\}$ Requir'd the Side AC .

Here the Perpendicular falls from the End of the given Side BC , and opposite to the Given Angle B ; then in the Triangle ADC is given the Angle at A , and the Side BC , to find the Side CD , which



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which being found, there is given in the Triangle ADC , the Angle at A , and the Side DC , to find the Side Required.

I shall not trouble the Book with the Operation finding Natural Radius, it having been often repeated in the former Part; but being found by *Method I*, the Natural Radius for the Angle 45 is 63.62 ; therefore, As 63.62 , to Side CB , 290 ; So 45 Angle at B , to Side opposite CD .

45	63.62	13050.00	(205	The Side CD
290		.326.00		
4050		.790		
900				
13050				

Now in the Triangle ADC , is given the Angle A $30^{\circ} 00'$, and the Side DC 205 , to find AC .

The Natural Radius found by *Method II*, for Angle 30 is 60 . Therefore,

As the Angle at A 30 , to Side opposite DC , So 60 to the Hypotenuse AC Required.

205	30	12300	(410	The Side AC Req
60		.3		
		.00		
12300				

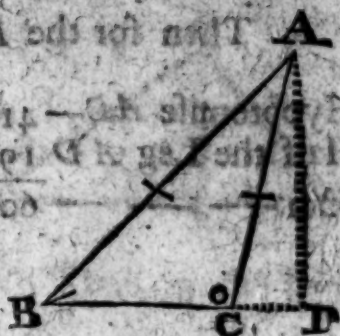
CASE II.

Given $\left\{ \begin{array}{l} \text{The Side } AB \ 560 \\ \text{The Side } AC \ 410 \\ \text{The Angle } B \ 45.0 \end{array} \right\}$ Required the Angle at C



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where the Perpendicular falls out, upon the Side BC . In the Triangle BCA there is given the Angle at B 45° ; and the Hypotenuse AB 560 , to find AD , which being found, you have in the Triangle CAD , Hypotenuse CA , and the Angle D 45° , to find the Leg CD , the Angle D 45° , and by Subtraction, the Angle A , and the Angle BCA , in their proper Case right-angled Triangles.



The Operation.

The Natural Radius for the given Angle 45° , is 63.62 , as found by Method I: Therefore, As 63.62 to Hypotenuse 560 ; So the Angle at B 45° , to Side AD .

$560 : 63.62 :: 25200.00 : 396$ the Side AD .

$45 : 6114.00$

$800 : 388.20$

$40 : 6.48$

200

then you have AD 396 , and AC 410 , to find by Rule III, thus:

the AC — 410 11284 (106, the Leg CD .)

the AD — 396 1

sum — 806 $20)012$

difference — 14 00

3224 $206)1284$

806 1236

product — 11284 (48)

Then

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Then for the Angle CAD , by Rule IV.

Hypotenuse AC	410	As 608 to 8, so 106
Half the Leg AD	198	Angle CAD .
Sum	608	106
		608)9116(14 ⁹⁴
		86
		626
		848
		9116

The Angle CAD is $14^{\circ}34'$, or rather 15 Deg which subtracted from 90 , leave ACD , 75 Deg and that subtracted from 180 , leaves 105 Deg the Angle ACB required.

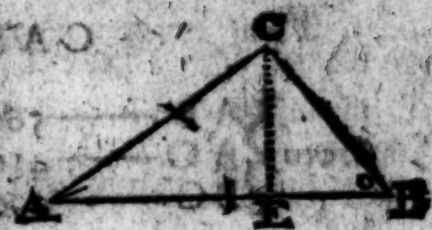
CASE III. Given as in Case II, to find the Side BC .

In the whole Triangle BDA , you have given Angle ABD 45 , and the Hypotenuse BA 560 so by Consequence, the Angle BAD , which is 45 , to find the whole Side BD ; but in this Case acute Angles being equal, viz. 45 Degrees, the BD is equal to AD , viz. 396 ; then having CD 106 , by the second Operation in Case II, subtract it from the whole Side BD 396 , the Remainder is the Side BC required.

CASE IV.

Given { The Side AC 410
The Side AB 560
The Angle at A 30.0 } Required the Angle

the Triangle AEC , is
the Angle at A 30° ,
the Hypotenuse AC
to find CE , which by
the first Case hereof is found
to be 205 , and therefore I



not repeat the Operation. Then in the same
Triangle AEC , there is given the Sides AC 410 ,
 CE 205 , to find the Side AE by *Rule III*.

_____	410	126075 (355, the Leg AE .)
_____	205	9
_____	615	65) 360
_____	205	725
_____	3075	705) 3575
_____	12200	3525
_____	126075	50

the Leg AE 355 subtracted from the whole Side
 AB 560 , rests EB 205 ; then in the Triangle BEC ,
we have given BE 205 , and EC 205 , to find CB by
Rule IV, and the Angle B by *Rule IV*; but in this Case,
and EB being equal, the Angle at B is proved
degrees, without Calculation.

CASE V.

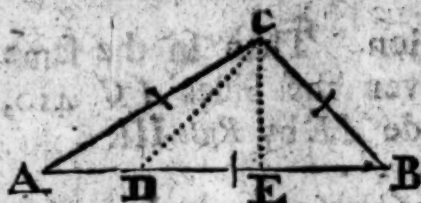
Given as in Case IV, to find the Third Side, BC .

though this is the Fifth Case in the Trigonometrical
operation, yet the Side BC is necessarily found in
Case IV, before the Angle at B can be found; and
therefore, altho' the Operation in Case IV be some-
times tedious, yet both the Fourth and Fifth Cases, are
included in it.

CASE

CASE VI.

Given $\left\{ \begin{array}{l} AB = 560 \\ AC = 410 \\ BC = 290 \end{array} \right\}$ Required the Angle at A



Find AE by the
laid down in *Axiom*
of *Plain Triangles*. As
Base AB 560, to the
of the other two Sides.
So the Difference of

said Sides 120, to the Difference of the Segments
the Base AD 150, as by the Operation below.

$$\begin{array}{r} 120 \ 56.0) 8400.0 (150 \\ \underline{700} \quad \quad 280 \\ 84000 \quad \quad \cdot 000 \end{array}$$

To the half Diff. 70
the half Base 280, the
355 is the greater Base
but subtracted, the

rence is the lesser Base EB 205.

Then in the Triangle AEC , there is given
410, and AE 355, to find CE by *Rule III*, and
Angle at A by *Rule IV*.

The Side AC — 410	42075 (205
The Side AE — 355	405) 02075
Their Sum — 765	2025
Their Difference — 55	50
	The Square Root
	42075, viz. 205
Product — 42075	Side CE required.

Then, by *Rule IV*, find the Angle at A .

Hypotenuse —	410
Half the longer Leg —	177.5
Their Sum —	587.5

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As 587.5, to 86: So C E 205, to the Angle opposite at A 30.

205	587.5)17630.0(30	The Angle at A
86	...5	Req.
1230	50	
1640		
17630		

Although this Method be not altogether so expeditious for oblique Triangles, as the Calculation by Logarithms, because you are obliged to divide every oblique Triangle into two right-angled ones, which sometimes requires two Operations; yet I thought to insert it to make the Method compleat, it being of great Use when Tables are wanting, and of sufficient Exactness for most Uses in Navigation; but the right-angled Cases, as perform'd hereby, I shall recommend to the Reader, as a Thing very useful, sufficient-exact, and as expeditious as any Method common in Use.

N S E C T.

S E C T. IV.

How to find the Difference of Longitude, keep a Reckoning both in Latitude and Longitude, by this New Method of Trigonometry, applied to Navigation) without the Help of any Tables or Instruments whatsoever, according to Middle Latitude, which is of sufficient Exactness for the Working so short a Distance as a Day's Run, and consequently of great Use in Navigation.

YOU may remember, that in *Middle Latitude Sailing Trigonometrical*, there is a Proportion finding the Difference of Longitude; which is, Sine Complement of Middle Latitude, is to the Departure: So is Radius to the Difference of Longitude. And therefore, in *Middle Latitude Sailing Geometrical*, one Way which I have proposed for projecting *Middle Latitude Sailing*, is by constituting a right-angled plain Triangle, whose Angle at the Base is equal to the Complement of Middle Latitude, and the Perpendicular is equal to the Departure: And then by the known Proportion of, Opposite Sides, Opposite Angles; it will necessarily follow, that the Hypotenuse must needs represent the Difference of Longitude, which being granted, there is no more to do for finding the Difference of Longitude, but only the Solution of the said right-angled Triangle; of the several Varieties of which you have had sufficient Instruction in the six Cases of *Plain Sailing* before going, when any two Parts being given, the other two are easily found. Nevertheless, that nothing may be wanted

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the Reader's Instruction, I shall instance in one question for Example's sake, which I shall first work by this New Method, and then by the Method proposed in *Middle Latitude Sailing Trigonometrical*; and finally, shall work the same by *Mercator*, to let the Reader see the Sufficiency and Exactness of this new useful Invention.

Question. A Ship in Latitude $58^{\circ} 00'$ North, sails with 25 Degrees, Easterly 96 Miles. I demand the Latitude come to, and also her Departure and Difference of Longitude.

The Course and Distance is the same as in the Question in *Case I* of *Plain Sailing*, as perform'd by this Method, and therefore I shall refer you to the operation there for finding the Difference of Latitude and Departure. The Difference of Latitude being found to be 87 , and the Departure $40\frac{1}{2}$, or 40.5 , therefore (the Course being Southerly) the Latitude come to is $56^{\circ} 33'$, and consequently the Middle Latitude, found by the Direction and Caution laid down in *Case I* of *Middle Latitude Sailing Trigonometrical* is $57^{\circ} 17'$, and the Complement of Middle Latitude is $32^{\circ} 43'$. From hence, by the fore-going Directions, is constituted the adjacent Triangle ABC , wherein the Angle at A is equal to the Complement of the Latitude $32^{\circ} 43'$; and the opposite BC , is equal to the Departure 40.5 ; both which are given to find the Hypotenuse AC , equal to the Difference of Latitude required; and here the opposite to the lesser Angle being given, I shall find Natural Radius by *Method II*. And

N 2



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here observe, that although, in Questions of *Sailing*, you need not regard Minutes in the Angle of the Course, because whole Degrees are exact enough to keep Account of a Ship's Way; yet in this Case you must not omit the odd Minutes in the Angle, and therefore reduce the odd Minutes to Tenths of a Degree, accounting 6 Minutes for one Tenth of a Degree, and 12 for two Tenths, &c. And then the Angle of 32 Degrees and 7 Minutes is 7 Tenths; and this Angle being 32.7 I shall call it 32.7, viz. 32 and 7 Tenths, it being but one Minute more, which cannot cause any Error in the Operation.

For finding Natural Radius, by Method II.

The Angle ——— 32.7
Mult. by its self 32.7
2289
654
981

Sq. of the Angl. 1069.29
Mult. by ——— 3

The Product 3207.87

Divided by 1000, the Product is 3.207, but it is exact enough to call it 3.2, which added to 57.3, the Sum is 60.5, the Natural Radius required.

Then, because the Hypotenuse is required, the Proposition is;

As the Angle 32.7, is to the opposite Side 40.5, So the Natural Radius 60.5, is to the Hypotenuse.

60.5 327)245027
40.5 1612
30.25
2420.0
2450.25

The Product of the Multiplication is but 2450, the other two Figures being Decimal Fraction, are cut off; but because the

for 32.7 is a Decimal, I add one Figure to the dividend, as you see in the Operation above.

The Difference of Longitude is 74.57, which is out exactly regarding the Fraction, may be seen

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And this Operation may be performed with great ease and Readiness, with a little Practice, although I have here set it down in Words at large, to make it more intelligible.

same Question answer'd by Middle Latitude Sailing Trigonometrical.

FIND Difference of Latitude and Departure, and consequently the Lat. come to, with Middle Lat. Complement of Middle Lat. as in Case I of *Middle Latitude Sailing Trigonometrical*, which will be found as above expressed.

Then for the Difference of Longitude.

As Sine Comp. Midd. Lat. — $32^{\circ} 43'$ —	9.73278
Is to the Departure — — — 40.5 —	1.60745
So is Radius — — — $90^{\circ} 00'$ —	10.00000
To the Diff. of Longitude — 74.9 —	1.87467

foregoing Question answer'd by Mercator's Sailing.

FIND Difference of Latitude, and consequently the Lat. come to, as in *Mercator's Sailing Trigonometrical*, and you will find the Latitude come to is $58^{\circ} 33'$, and the Departure $40\frac{1}{2}$ or 40.5 .

Latitude saild from — $58^{\circ} 00'$ —	} Merid. Parts {	4294
Latitude come to — $56^{\circ} 33'$ —		4133
Meridional Difference of Latitude — — —		161

N 3

Then

	Then	Co.
As proper Difference of Latitude—87 —		8.06
To Merid. Diff. of Latitude ———161 —		2.20
So is the Departure ————40.5 —		1.60
To the Difference of Longitude—74.9 —		11.87

And thus you see the exact Agreement of this with the true Operation, as performed by *Mercator's Sails*; it not differing from it so much as one Quarter Minute in Longitude, in so great a Distance as 58 Miles, and in a Latitude so near the Pole as 58 degrees, where there is much more Danger of committing an Error than in lesser Latitudes, or Voyages nearer the Equinoctial.

CHAP. VII.

Practical Navigation :

O R,

The Application of the foregoing Rules to the Actual keeping of a Reckoning, according to the several Kinds of Navigation

TH E R E are four Things very necessary to be known by all that take upon themselves the Charge of Conducting a Ship from one Part of the World to another, which may properly be called the Practical Part of Navigation,

The first is a right Understanding of the Compass, and the Variation thereof, in order to the true Knowledge of the Course made good.

The second is the Log-line and Half-minute Glass, the Knots on the Log-line be a due Length, and the Glass be a just Half Minute, that thereby you as near as possible find the true Distance.

The Third is the right Manner of taking and working an Observation by the Sun by Day, or by the Stars by Night, thereby to find the true Latitude, and to correct the Dead Reckoning, if there have been an Error contracted either in the Course or Distance.

And fourthly, having by these Means and Helps directed your Reckoning, and being come near the desired Port, it is also necessary, that there be a right Understanding of the Tides, which Way the Ebbs and Floods sets, and what Moon makes full Sea upon any Coast, that so it may be known how long to ride at Anchor, or lie by to wait the Tide, if you know you will be too soon; or what Sail to make to save your Tide, if you fear being too late: And these four Things I will handle in this Part, and that in such a Manner, that they may be intelligible to the meanest Capacity, and most useful and easiest to be put in Practice at Sea.

SECT. I.

Of the Variation of the Compass.

THE Way commonly taught for finding the Variation of the Compass, is by the Sun's Azimuth, or Amplitude; but these Ways not being attainable by but them that have learned something of Astronomy; and being also treated of in other Books, I

shall not trouble the Learner with them, but proceed to a far easier Way, which is this.

When you are at Sea, and desire to know the Variation of the Compass, take your Quadrant about 8, or 10 a Clock, when you suppose the Sun is about half up from the Horizon to the Meridian, take an Observation of the Sun's Altitude, as would do at Noon, to find the Latitude of the Place which being done lay by your Quadrant (letting Vanes remain unremoved) and by your Azimuth Compass (if you have one aboard) set the Sun, mind what Point of the Compass the Sun is upon that Observation. This done wait till the Afternoon till the Sun grow almost as low as he was when observed in the Forenoon, and then with your Vanes fixed, as in the first Observation, observe till the Sun be so low as that the Vanes so fixed will just take the Sun's Altitude without altering them; which do observe immediately (as before) upon what Point of the Compass the Sun is at that Observation: The Space between that Point which the Sun was upon the first Observation, and that Point upon which the Sun was at the last Observation, divided into two equal Parts, the Middle is the true South Point of the Compass, and the Distance between that and the Point of the Card, is the Variation required.

Example.

Suppose at the Forenoon Observation I find the Sun by the Compass to be South-East (it matters not what his Altitude be, so you mind what it be, or else let the Vanes stand un-removed till the Afternoon) and suppose in the Afternoon I find, when the Sun hath the same Altitude, that he bears West South West; the Distance between South East and West South West is ten Points, the Half of that is five Points, which reckoned from South East towards the West South West, it falls upon the South and by West; there

conclude that the South and by West Point of the Compass points to the true South Point, and the Distance between the South and by West Point (which is the true South) and the South Point of the Compass (which we may call false South, or magnetical South) is the Variation of the Compass; and because magnetical South is Eastwards from the true South, therefore the magnetical North is Westward from the true North. Hence I conclude, that the Variation is one Point Westerly, &c.

In this Case there is only this Caution to be observ'd, that this Observation be not made when the Ship is running very fast Northwards or Southwards, which may make some small Error, though scarce discernable; for if the Ship stood still, the Sun would have nearly the same Altitude at 8, 9, 10, in the Forenoon, that it would have at 2, 3, 4, in the Afternoon; but if the Ship sails very fast to the Southward in North Latitude, or to the Northward in South Latitude, she raiseth the Sun a little; and by Conference the Sun will be somewhat higher at 4 in the Afternoon than at 8 in the Morning, and may cause some Error, but it is little, and a Thing that seldom happens: And if it do happen that your Course be North or South, and the Wind so fair, you may defer your Observation till another Day, (it being not necessary to set the Variation every Day) and thereby Error may be avoided, and yet the Variation easily found as often as is necessary.

SECT.

S E C T. II.

How to divide the Log-line, and try a Half Minute Glass.

TH E Y that take upon them to be Master, Master or Pilot of a Ship, and would be very exact and accurate in the keeping a Reckoning, or Account of the Ship's Way, ought to take Care before they go from the Shore, to be furnish'd with all Things necessary for that Purpose : For the best of Scholars, the greatest Artists, the most profound Mathematicians, or the most experienced Navigator, may be deceived, and carried into gross Errors, by a Defect in their Instruments, or Means for keeping a Reckoning, as well as the more Ignorant may be by a Defect in their Knowledge ; and so far as they design that their Account shall depend upon their dead Reckoning, they ought chiefly to be careful in these two Things.

First, The Half-Minute Glass that it be of a proper Length ; for if it be longer than it should be, it may make the Ship by Estimation to run so much more than it really does, and by that Means, perhaps, in a Month or 6 Weeks Sailing, you will expect to arrive at your Port, or make such or such Land, when in deed you are 50, 60, or 80 Leagues, or more or less short of it, according as the Error of your Glass is more or less. And although it is hard to know a true Half-Minute Glass, yet there are these two Ways to prove them, and know whether they are right or wrong.

The first Way is by an Experiment mentioned by Mr. Henry Phillips, in his *Advancement of the Art of Navigation*, and also quoted by Mr. Saller, in his *Practical Navigation*, and 'tis this : Take a Bullet of any con-

ent Weight, it matters not, and make fast to it a
ce of fine Thread, or Silk, of the just Length of
Inches; let there be a Noose on the End of the
lead, and let the very End of the Noose be just
Inches from the Center of the Bullet, (as I said
re) then hang it up by the Noose upon a small Pin,
re it may hang at Liberty, and swing freely, and
ive it Way; and each Swing shall be a true Second
Time; that is, each Time that it passes by the Per-
pendicular let fall from the Pin on which it hangs,
be half a second; and every Time of its Re-
to the Place where it first begun its Motion, is a
Second of Time, and a Glafs that runs till the
Bullet hath made 30 Returns, shall be a true Half-
minute Glafs.

Second Way (if it may properly be so called) is
the Experience of those that have had Occasion to
a Glafs in long Voyages; and having a Line right-
divided, and a Glafs of so true a Length, that their
Reckoning, when carefully kept, hath agreed
to the Truth of their Observations; and that their
Latitudes, (when found by Observation) their
ing of Land, &c. hath fallen out according to
expectation, by the dead Reckoning; I say such a
s, or another of the same Length, ought to be
ferred before any other, as a true Half-Minute
s.

second Thing necessary, in order to the Keep-
of a true Reckoning, is to take Care that the
line be rightly divided; for although the Glafs
true, yet if the Log-line be divided into Knots too
or two short, it must needs make an Error in the
Reckoning, according to the Proportion of the Error
Divisions of the Line, if you work by a true Half-
minute Glafs. Indeed, if the Divisions of the Log-
be too short, and the Glafs also too short, (or if
be too long, which is the same) then the one Er-
helps to compensate the other; but if the Faults in
the

the Line and in the Glas be contrary, that is, the too long, and the other too short, the Fault is irremediable.

As for the Length of each Knot on the Log-line how it should be divided, there are different Opinions amongst different Authors and Navigators. Indeed it is an undeniable Truth, and apparent to all Reason, that one Knot upon the Log-line should be the 120th Part of a Mile; because Half a Minute is the 120th Part of an Hour; (for as the Whole is to the Whole, so a Part to the Part, &c.) but the Difference arises from the different Opinions, as to how many Feet, Yards, &c. there is in one Degree of a great Circle upon the Earth. Mr. Oughtred, in his Circle of Proportion, will have $66\frac{1}{2}$ Miles to answer one Degree upon the Earth, each Mile containing 5280 Feet. Hence there is by his Account, 349800 Feet in one Degree of a great Circle, upon the Earth, 5830 Feet in one Minute, or 60th Part of such a Degree, and consequently the 120th Part of a Minute or Length of one Knot upon the Log-line, must be $48\frac{1}{2}$ Feet.

But Mr. Norwood, in his *Seaman's Practice*, publishes (relating an Experiment of his for finding the Quantity of one Degree of a great Circle upon the Earth) that one Degree contains 367200 of our English Feet to a Degree, which Account, without any Allowance, would give 51 Feet to one Knot of the Log-line, although, for Reasons there mentioned, he allows 1 Foot out of the 51, and so would have one Knot of the Log-line to be just 50 Foot. But how far his Experiment of his is to be depended upon, (considering the Unevenness of the Ground, and Crookedness of the Ways, and other Inconveniences, which could only give Allowance for according to his Judgment) and also how far that one Foot in 51 may compensate the Way that the Log makes after the Ship shall not take upon me to determine. In the mean

I shall, with Submission to better Judgments, adhere to the Way of dividing the Log-line that commonly received and used by most Mariners, I that of 42 Feet, or 7 Fathom to one Knot. it will presently be objected, that according to Division for half a Minute, multiplying that by for 1 Mile or Minute, and that Product by 60, Degree, there is by consequence but 302400 Feet Degree, which seems to contradict, and intol- to vary from the Opinions of the ingenious Mr. Wood, and other experienced Men in that kind. answer, It doth not contradict them, at least so as at first Appearance it seems it doth, for one Reason why I agree to these shorter Divisions to give Allowance for the Way that the Log makes the Ship; for although there is so much stray allow'd, as may be supposed to veer the Log erately well out of the Eddy of the Ship's Wake, it cannot be supposed, but that still the Log must e some Way after the Ship, if but by the Weight of Line, which although but light, yet the Water g but a soft fluid Substance, the Log must needs e a Motion after the Ship, and especially sailing e, and in a fresh Gale, it cannot be but that the d will have so much Effect upon the Log, and so ch of the superficial Part of the Water, as to ve it along after the Ship, and that, in my Opini- much more than one Foot in 51. Indeed another Consideration, which may be ac- nted a second Reason why I do adhere to that y of dividing the Line, is, because if there is an Er- it is on the safer Side; for although the Truth is t, if it could be attain'd, yet if an Error must be, better that the Reckoning be a-head of the Ship, n that the Ship should be a-head of the Reckoning; d better to look out for Land before we come at it, n to be a-shoar before we expect it.

But

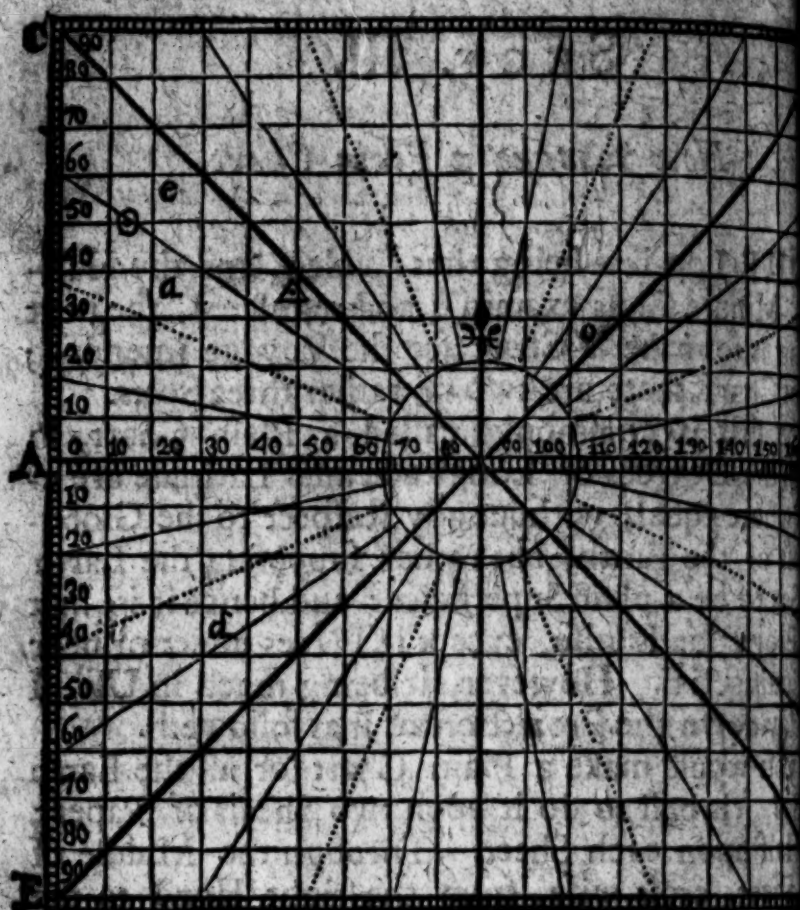
But my third Reason is, the Confirmation of my Opinion by the daily Practice and Experience many, if not most Mariners, who use this Way, find the Success to answer their Expectations, as much nearer than a much larger Division would 'Tis true, if the Generality of Glasses be so much short, as to countervail those too short Divisions, they are too short) it were to be wish'd, that the rors in one were rectified, and then the Faults in other might be amended; but till then I shall recommend that Way of allowing 42 Feet, or 7 Fathom one Knot of the Log-line. Indeed if it be, as it is reported by some, that to make Amends for the Shortness of the Knots, the Glasses are commonly made 27 Minutes; and if so, then if the Glasses were regulated and increased from 27 Minutes to 30, the Knot by the same Proportion, should be also increas'd from 42 Foot to 46 $\frac{1}{2}$ Feet to one Knot, which seems agreeable to Reason, and to Mr. Norwood's Observation.

Note, When you divide the Log-line you must allow 12, 15, or 18 Fathom of Stray-line, according to the Bigness of your Ship, accounted from the Log, before you begin to set out the Knots, and there put in a red or white Rag, and from thence begin to divide the Line into Knots. The Reason of the Stray-line is to veer the Log pretty well out of the Ship's Wake, lest the Eddy should suck the Log after the Ship, and deceive you in your Reckoning.

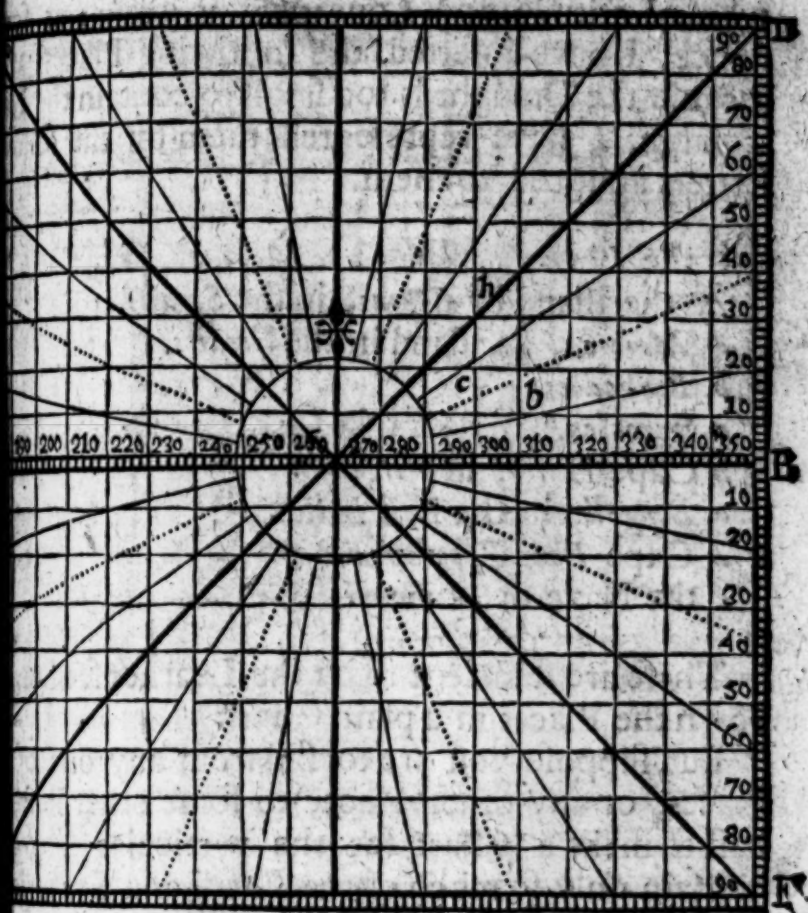
SECT. III.

How to make a Plain Chart.

THE Log-line being thus divided, and the Half-Minute Glass examin'd and regulated, the next thing is to make a Chart for the Voyage intended; of Charts there are two or rather three Sorts. The first is commonly called a Plain Chart, in which the Degrees of Longitude and Latitude are everywhere equal, without any Respect to the Globulosity of the Earth, but rather supposing the Earth's Sea to be a plain Superficies; and hence it is, that this Projection is false, except in Places under or near the Equinoctial. However, it being much in Use, I lay down the Projection of it as followeth. If you would make a Plain Chart for all the Earth's Sea, 'tis best to do it upon two Sheets of Paper; Half upon each Sheet. Through the Middle of each Sheet, cross-wise, from the right Hand to the left, draw the spotted Line *AB*, which divide into equal Parts, by any equal Parts of the Scale, as many as your Paper will contain, which you may mark every 10 Degrees with Figures, 10, 20, 30, &c. So, beginning at any Place where you intend to reckon your Longitude from, which suppose let be *Teneriff*, let your Chart begin at the West or left Hand, and so reckon Eastwards, as in the following Example, where the two Charts contain all the 360 Degrees of Longitude in Compass, and 90 Degrees of Latitude each Way from the Equinoctial. Then in the Middle of the Chart, as a Center, draw the Points of the Compass, as you see done. Then in inserting any known Place in the Chart, find by the Table of Latitude and Longitude of Places, what Latitude



Latitude and Longitude your Place hath, and plot
 in that Latitude and Longitude in the Chart; as
 Example, Suppose I would insert the Land's End of
 England, and the Island of Cyprus in the Straits,
 would find their Bearing and Distance; according
 the Plain Chart, I find the Latitude of the Land's End
 of England in the Table is $50^{\circ} 00'$ North, and Longitude
 $12^{\circ} 37'$, I reckon upon the Line AB , which is
 the Equinoctial, till I come at 10 Degrees, and adding
 2 of the small Divisions for other 2 Degrees, which
 make 12 Degrees, and as near as I can compute, I find
 what more than Half of another small Division, for
 37 Minutes, and setting one Foot of the Compass on
 that Mark, I extend the other to the next North



Line, and running them up into Latitude 50°
 I make the Mark $\odot$ to represent the *Lizard*; and
 the same Method I find the West End of *Cyprus*, at
 Mark Δ , then the Distance between these two
 is taken in your Compass, and applied to the E-
 ast Line *A B*, accounting every Degree 60
 Miles, and every 10 Degrees 600 Miles, gives the
 Distance between the two Places, according to the
 Chart; and then for the Course, observe what
 Point of the Compass, a Line supposed to
 be drawn between these two Places would be parallel
 to, which in this Case you see is an E.S.E. and W.N.W.
 the nearest Point representing the Course re-

O

In

In like manner you may insert any other Place whose Latitude and Longitude is given; as for instance, I have inserted the following Places, because the Draught is too small to contain the Names at large, I have represented them by the following Letters annexed to them.

⊙ the *Lizard*.

Δ the Island of *Cyprus*, in the *Straits*.

a *Majorea*, an Island in the *Straits*.

b *Barbadoes*.

c *Jamaica*.

b Cape *Henry*, in *Virginia*.

o *Bengall*, in the *East Indies*.

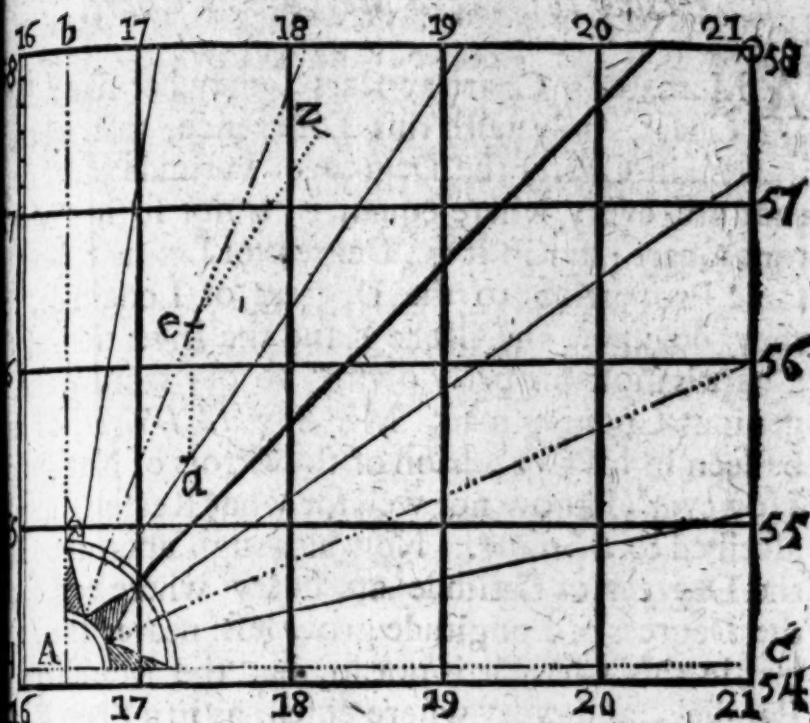
d Cape *Bona Esperanza*.

e the *Naze of Norway*.

These are sufficient to let the Learner see how down the Places in a plain Chart.

But suppose you are to sail from any one of the Places, or any other Place, to some other Port, best to make a Chart for the particular Voyage contain only so much of the Earth and Sea as is contain'd between the two Places, or little more, and you may make your Degrees of Latitude and Longitude larger, as in the following Example.

A Ship sets Sail from *Flamborough Head*, in Latitude 54° 08' North, and Longitude 16° 26', intending the *Naze of Norway*, in Lat. 58° 00', and Long. 21° 00'. I desire a Chart made for that Voyage.



This Chart is made to contain from 54 to 58 of Latitude, and from 16 to 21 of Longitude; and then by the former Rules, the Point *A* represents *Flam-
borough-Head*, and the Point $\odot$ upon the opposite Cor-
dure is the *Naze of Norway*: Then at *Flam-
borough-Head*, the Place sail'd from, as a Center, I describe
a Quarter of a Compass, which in this Case is always
true, and thus is the Chart ready for the Voy-

age as for setting off the Courses and Distances, or
the Difference of Latitude and Departure, upon a Chart,
commonly call'd, *Pricking a Chart*, I shall refer it till
I come to give some Examples of keeping a Journal by
Log and Compass.

How to make a Mercator's Chart.

A Mercator's Chart appears somewhat like a Plain Chart, only with this Difference, that where in a Plain Chart, the Degrees of Latitude and Longitude are every where equal, it is not so in a Mercator's Chart ; for in it the Degrees of Latitude bear the same Proportion to the Degrees of Longitude, that they do upon the Globe ; and the Invention of this Chart is most properly owing to our worthy and ingenious Country-man, Mr. *Edward Wright*, as may be seen in his *Correction of the Errors of Navigation*. However (I know not well for what Reason) unjustly ascribed to *Mercator*. Now although upon the Globe the Degrees of Latitude are every where equal, and the Degrees of Longitude grow less nearer the Poles, yet in this Chart it is not so, but the Meridians and Parallels, and every where equal, as in a Plain Chart, but the Degrees of Lat. grow bigger near the Poles, so that in a *Mercator's* or *Wright's* Chart, there is always the same Proportion between a Degree of Latitude and a Degree of Longitude, in any Parallel, as there is upon the Globe its self.

For the Projection of this Chart, there are several Lines upon *Gunter's* Scale, commonly placed next the Bottom, on that Side upon which the Logarithmic Numbers, Sines, and Tangents are ; the lowest of these two, is a Scale of equal Parts, and the next to it, called the Meridian Line, by the Help of which you would draw a large Chart of all the World between 85 Degrees of North Latitude, and 85 Degrees of South Latitude, you must prepare large Paper, paste Sheets of Paper together, till your Sheet comes to about 4 Feet each Way ; through the Middle of which draw the Equinoctial Line, as you see in the Plain Chart before inserted, and graduate it with 10, 20, 30, &c. by those Divisions upon the Line of equal Parts.

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arts now mention'd, which done, when you see how the 180 Degrees of Longitude reach (if you make the Chart in two Parts, or the 360 Degrees, if you make it all in one Draught, as your Sheet of Paper 4 Foot square will easily contain) and there draw Lines at right Angles, with the Equinoctial Line, as you see in the foregoing Charts, the Lines *CAE*, and *DBF*, then these Lines graduated from *A* the Equinoctial, both Ways, by the Graduations upon the Meridian Line upon the Scale, shall set off every Parallel of Latitude according to *Mercator*; and when the Lines on both Sides are so graduated upwards and downwards, from the Equinoctial, the Lines drawn from every Degree on one Side to the same Degree on the other Side, shall represent the Parallels of Latitude required.

But because these Graduations would be too small to make a Chart by, for any particular Voyage, it is better to make the Chart larger, and in that Case, the Length of a Meridian Line so large, may be supplied by a Table of Meridional Parts; for having drawn the Equinoctial, or any other Parallel of Latitude, which is the same, for one Out-side of your Chart; set off 60 of any equal Parts for every Degree of Longitude, both at the Top and Bottom of your Chart; then, if you have done, find (by the Rules laid down in *Mercator's* *Trigonometrical*) the Meridional Difference of Latitude, or the Meridional Parts contain'd between one Degree and the next, these taken from the same Table of equal Parts, and set from the last Degree set off, shall find the next Degree, and so in the rest. The Rumbs, or Points of the Compass, are exactly the same as in a plain Chart.

I shall explain what hath been said by an Example of *Mercator's* Chart, from *Flamborough-Head* to *Norwich*, before mentioned.

	Lat.	Long.
Flamborough Head —————	54° 8'	16° 26'
Naze of Norway —————	58 0	21 00

It is best to make the Chart to a whole Degree, as in this Example I shall, as before, make it from Lat. 54 to 58, and from Long. 16 to 21.

Merid. Parts for Lat. 58° 0'	4294
Merid. Parts for Lat. 54 0	3865

Merid. Diff. of Lat. in the whole Chart	429
Diff. of Longitude in the whole Chart	300

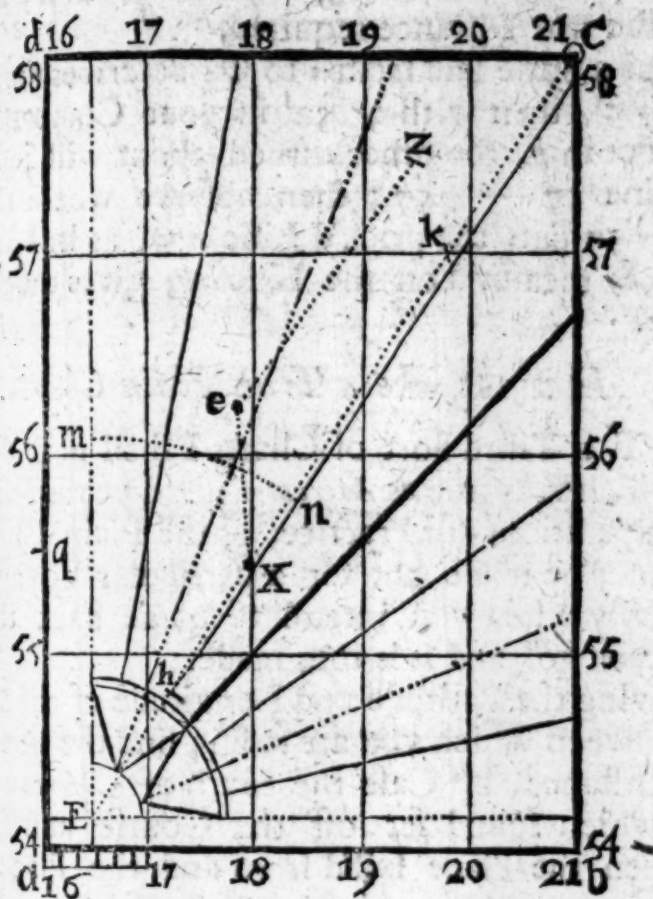
Having drawn the Line *da*, set off the whole Meridional Difference of Latitude 429, off any convenient Scale of equal Parts, from *d* to *a*, and draw *ac* and *dc*, perpendicular to *da*, and set off the whole Difference of Longitude 5 Degrees, or 300 Min. from *d* to *c*, and from *a* to *b*, and draw *cd*; thus you have the whole Substance of your Chart.

Then set 60 of the same Parts from *d* to 17, and from 17 to 18, and from 18 to 19, &c. both upon Line *dc*, and upon the Line *ab*, and draw the Lines 17—17, 18—18, &c. thus is your Longitude graduated.

Then for the Latitude, find the Meridional Difference of Latitude, between Lat. 54 and 55, which is 103, therefore set 103 of the same equal Parts from 54 to 55, and from *b* to 55, and draw the Line 55—55, then find the Meridional Difference of Latitude between Lat. 55 and Lat. 56, which is 106, which set from 55 to 56, on both Sides, and draw the Lines 56—56, and so find also the Line 57—57. Then upon the Center *c*, which represents the Pole, draw a Quarter of a Compass, the Radius whereof upon that Compass shews the true Course from Flamborough Head to the Naze of Norway.

Fig. 3. How to make a Mercator's Chart. 199

ough-Head, at the Point *e*, to the Naze of Norway, the Point *o*, which you see differs much from the Course found by the Plain Chart.



The Distance between any two Places in a Mercator Chart is thus found: Find the Difference of Latitude between the two Places, which here is $3^{\circ} 52'$, or 52 Minutes, which set off upon the Line *ab*; take 3 whole Degrees from 17 to 20, and the 52 Minutes of the graduated Degree, accounting every Part 10, because the Degree is divided into 6 Parts; then opening your Compasses at that Extent, lay a Ruler as that it may just cut the two Places, whose Distance is required; then set one Foot of your Compasses at the Ruler's Edge, so as that the other turned out may just touch some East and West Line, then

O 4

keeping

200 *How to make a True Plain Chart.* Ch

keeping that Foot fast that stood against the Ruler, open the other to the Crossing of the Ruler, the said East and West Line, that Extent measured the Parallel *ab*, allowing 60 Miles to every Degree gives the true Distance required.

Thus a Scale laid from *a* to $\odot$, describes the prick'd Line *a* $\odot$, then with $3^{\circ} 52'$ in your Compasses, one Foot in *b*, the other turned about will just touch the Line $57-57$; then observe where the $57-57$ cuts the prick'd Line *a* $\odot$, as in *k*, the extent *bk*, measur'd on the Line *ab*, gives the true distance.

How to make a True Plain Chart.

BUT a Third Sort of Charts I shall next describe which is as true as *Mercator's*, and yet as plain, and expeditious for Practice, as the Plain Chart; it cannot be made but for a particular Voyage, generally when you intend to come back the same Way you go, and it is thus made.

Having the Latitude and Longitude of the two Places between which you are to sail, find the true Course and Distance, by Case the Sixth of *Mercator's Sailing*, which found set off the Course and Distance between the Place sail'd from and the Place bound for, as you are taught in *Traverse Sailing Geometrical*; so have you two Points representing two Places, and if your Ship sail upon several Courses you may lay down all her several Courses and Distances, in form of a Traverse, as you are taught in *Traverse Sailing Geometrical*, and so you may every time set off the Course and Distance from the Ship to the Place bound for, according to *Mercator*, and yet done as easily as in *Plain Sailing*, I shall instance in the fore-mentioned Voyage.

Lat. L

A Ship sails from *Flamborough-Head*— $54^{\circ} 8'$ —16
Intending for the *Naze of Norway*— $58^{\circ} 0'$ —21

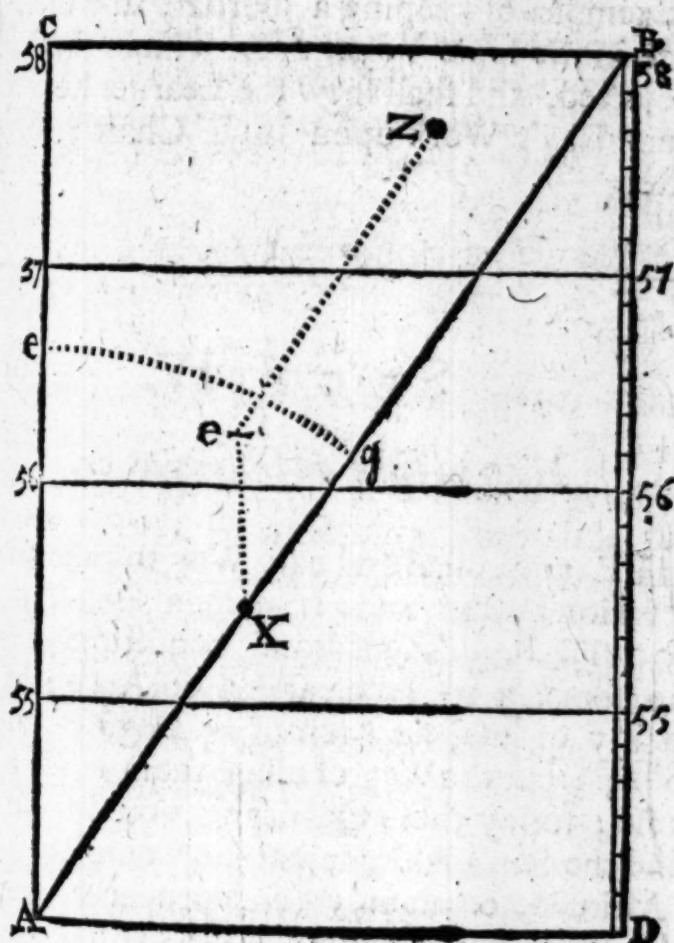
3. How to make a True Plain Chart. 201

For the Course, according to Mercator.

As Merid. Diff. Lat.	416	2.61909
to Radius	90° 00'	10.00000
so is Diff. of Long.	274	2.43775
To Tangent of the Course	33 22	9.81866

Then for the Distance.

As Sine Comp. Course	33° 22'	9.92177
To proper Diff. of Lat.	232	2.36548
so is Radius	90 00	10.00000
To the Distance	278	2.44371



Here

Here *A* represents *Flamborough-Head*, *B* the *Naze* of *Norway*, the Line *AB* the true Distance, 278 Miles, the Angle *CAB* $33^{\circ} 22'$, the Course from the Meridian, and in this Chart the Degrees of Latitude, are equal Divisions, and easily represented, but the Degrees of Longitude, if they were inserted here, would be curved Lines, and hard to project; nor is it needful, seeing upon this Chart you need not regard the Longitude as you go along, but only the Course, and Distance upon each Course, according to the Rules laid down in the second Question of *Traverse Sailing Geometrical*.

Having thus shew'd how to make the several Charts, I shall shew the Use of them when I come to give some Examples of keeping a Journal, in which I shall instance in the same Voyage for which these Charts are projected, and shall shew the Learner how to prick off every Day's Work upon each Chart; of which hereafter.

S E C T IV.

How to take an Observation.

TH E most usual and easy Way to take an Observation by the Sun, is with a Quadrant, commonly call'd *Davis's Quadrant*, consisting of two Arches in some, a 30 Arch, and a 60 Arch; but more commonly of late, an Arch of 25 Degrees, and another of 65; but the Way of using them is all one and the same; for by these Quadrants you do not so readily find the Sun's Altitude, but the Complement of the Sun's Altitude, commonly (and properly) called the Sun's Zenith Distance, being the Sun's Distance from the Zenith,

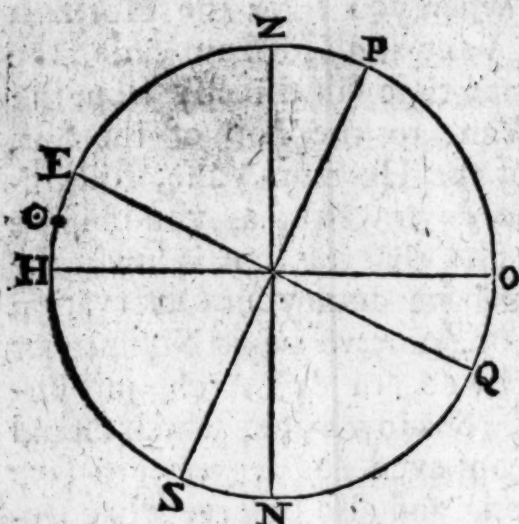
Zenith, or Point right over our Head, which is easily found by one of these Quadrants; for having fitted your Vanes so, as that when you have the Horizon right through the Sight Vane and Horizon Vane, the Shadow may at the same time fall directly from the Top of the Shadow Vane to the Top of the Slit, (which is the Middle) of the Horizon Vane, still removing the Sight Vane downwards, as you observe the Sun to rise, till you find that the Sun is upon the Meridian, and then you have done your Observation for that Day. This done, observe what Number or Figure you have upon the 60 (or 65) Arch, just under the upper Edge of the Shadow Vane, (which should always be placed upon an even 10 Degrees, to save Trouble in the Addition) and also observe what Degree and Minute you have upon the 30 (or 25) Arch, just under the Middle of the Sight Vane, even with the Line or Stroke that goes from the Hole along the Middle of the Vane; and these two Numbers added together, the Sum is always the Zenith Distance, which is to be used as in the following Directions for working an Observation.

How to Work an Observation.

There are but four Cases, or Varieties in working an Observation, in whatsoever Part of the World you be, or whether the Sun's Declination be North or South.

The first is, when the Sun is between the Horizon and the Equinoctial, and then the Rule is, Subtract the Declination from the Zenith Distance, the Remainder is the Latitude of the Place.

Demon.

Demonstration.

plement of the Sun's Altitude. Now if from $\odot Z$ the Zenith Distance, you subtract $\odot E$, the Sun's Declination, there remains $E Z$, the Latitude of the Place of Observation.

Example.

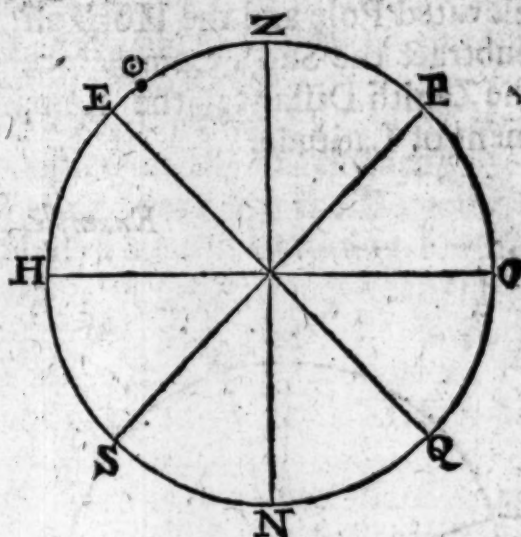
Suppose the Sun's Zenith Distance be $76^\circ Z \odot$, and the Sun's Declination South is $E \odot 16^\circ$, subtract $\odot E$ the Declination 16° , from $\odot Z$ the Zenith Distance 76° , there rests $E Z 60^\circ$, the Latitude required.

The second Variety is, when the Sun is between the Equinoctial and the Zenith, and then the Rule is, Add the Zenith Distance to the Sun's Declination, the Sum is the Latitude of the Place: For if to $\odot Z$, the Zenith Distance, you add $\odot E$, the Sun's Declination, the Sum is $E Z$, the Distance between the Zenith and the Equinoctial, which is the Latitude required.

Example.

Example.

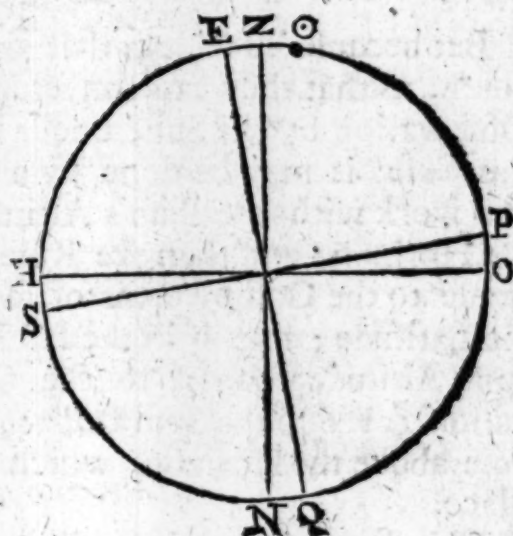
Suppose the Sun's Zenith Distance $\odot Z$ 35, the Sun's Declination North $E\odot$ 10, if to $\odot Z$ 35 the Sun's Zenith Distance, you add $E\odot$ 10 the Sun's Declination, the Sum must needs be EZ 45, the Latitude required.



The Third Variety is, when the Sun is between the Zenith and the elevated Pole, and then the Rule is, Subtract the Zenith Distance from the Declination, the Remainder is the Latitude of the Place;

Example.

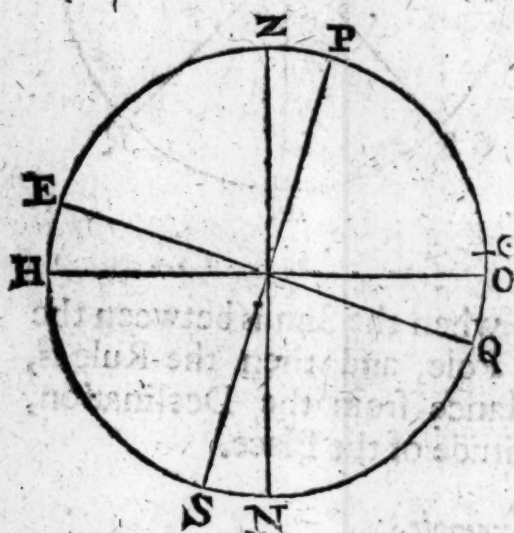
Suppose the Sun's Declination be $E\odot$ 20, and the Zenith Distance $Z\odot$ 10; subtract the Zenith Distance $Z\odot$ 10, from the Sun's Declination $E\odot$ 20, there rests EZ 10, the Latitude required.



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The Fourth Variety is when the Sun is between the elevated Pole and the Horizon, and then the Rule is, Subtract the Sun's Complement of Declination from the Zenith Distance, the Remainder is the Complement of Latitude.

Example.



Suppose the Sun's Declination be 22, (its Complement is 68) the Zenith Distance 85, then from Zenith Distance $\odot Z$ 85, subtract the Complement of Declination $\odot P$ 68, the Remainder $Z P$ 17, is the Complement of Lat. which subtracted from 90, leaves 73, the Latitude required.

But because 'tis seldom that any sail so far North or South, as that they can conveniently take a backward Observation by the Sun, under the elevated Pole, in this Case, it may be done by a forward Observation, and work with the Sun's Altitude or Height above the Horizon, and then the Rule is, Add the Sun's Altitude to the Complement of Declination, the Sum is the Latitude; thus if in the last Example, you add the Sun's Altitude, $O \odot$ 5, to the Complement of Declination $\odot P$ 68, the Sum $O P$ 73, is the Height of the Pole above the Horizon, which is the Latitude of the Place.

This same Operation will hold in taking an Observation by a Star, when under the elevated Pole, because

Sect. 4. How to work an Observation. 207

because both here, and in all other Cases in observing by the Stars, we are obliged to take the Observation forward, because a Star casts no Light sufficient for a backward Observation, and then, instead of the Zenith Distance, work with the Altitude.

In forward Observations, whether by Sun or Stars, there are also four Varieties, as in a backward Observation, which I shall only speak to, the Demonstrations being pretty evident from the foregoing Figures.

The first Case is, when the Star is between the Equinoctial and the Horizon, and then the Rule is, Add the Altitude of the Star to its Declination, the Sum is the Complement of Latitude, which subtracted from 90 leaves the Latitude required.

Secondly, When the Star is between the Equinoctial and the Zenith, subtract the Star's Declination from its Altitude, the Remainder is the Complement of Latitude.

Thirdly, When the Star is between the Zenith and the elevated Pole, then subtract the Complement of Declination from the Altitude, the Remainder is the Latitude.

The fourth Variety is spoke to in the fourth Variety before going; and so much shall serve for the working an Observation; these Rules, if well observed, being sufficient for working Observations in all Latitudes, whether North or South, and at all Times of the Year, as a little Practice will make evident.

It is possible to take an Observation by the Moon; but there are so many Things to be accounted for, as Parallax, Refraction, &c. and the Moon being seldom to be seen, but when some known Star may also be seen, and I having in this Book inserted a Table of fixed Stars, their Declinations, &c. I shall refer the Reader to it, the Sun and Stars being sufficient in all Cases for taking Observations.

SECT.!

S E C T. V.

How to reckon the Tides.

Of the General Motion of the Tides. and how to know the Time of High-Water at any known Port, only by a Sight of the Moon at any Time of the Day or Night.

THEY that would be able to give a good Account of the Tides, or of the Time of High-Water or Low-Water, at any Port or Harbour propos'd, it is necessary, in order thereunto, that there be a right Understanding of the original Cause of the Motion of the Tides, or Ebbing and Flowing of the Sea; a Thing which hath been often in Dispute among the Learned, both Mathematicians and Philosophers, whose different Sentiments have rendred the Thing as dubious as when they first began with it; some ascribing the Motion of the Sea to the swift Motion of the Earth, according to the *Copernican* System, and that the Water being a fluid Body, and not presently acquiring so swift a Motion as the Earth it self, it must consequently be higher Water upon one Part of the Globe than upon another, and this they illustrate thus: Suppose a Boat under Sail, with fresh Way, and a small Quantity of Water in the Boat, it seems very plain, that the swift Motion of the Boat would make the Water incline rather towards the Stern of the Boat; but if the Boat, when sailing with that Speed, should by coming ashore, or some other Accident, meet with a sudden Interruption, and at once give over her Motion, the Water still retaining in some Measure its former Motion, will presently run to the Fore-part of the Boat, and by this they would some Way or other demonstrate, that the Motion of the Tides depends upon the Motion of the Earth: But to use no other Arguments for the Confutation of this Opinion, the Absurdity hereof

hereof will appear in this ; that if the Motion of the Earth were the original Cause of the Motion of the Tide, then the Tide must necessarily follow the Motion of the Earth, (or to our Appearance the Motion of the Sun) and consequently it must always be High-water at one Place, at one and the same Time of the Day ; but the contrary is so evident to all, that there needs no more be said to disprove it.

Others say, the Flowing of the Tide is occasion'd by a great Confluence of Water proceeding from the Mael-stream, (called by some the Navel of the Sea) being (as it is reported) an Eddy, or Whirl-pool, upon the West Coast of *Norway*, or *Finmark*, from whence (it is said) during the six Hours Flood, the Water issues violently out, and occasions the Rising or Flowing of the Water in all the adjacent Parts, and sinks with the same Violence during the Ebb ; so that it is said, that during the Flood, the heaviest Metal will not sink ; and during the Ebb, the lightest Substance, or the best of Ships, will not swim ; but what Reason they will give why this Ebbing and Flowing should be regulated and governed by the Motion of the Moon, I do not understand, unless this Issue of Water be supplied by some Communication that it hath with the *Eastern Seas*, by some Passage under the main Continent of *Norway* ; but this being an Uncertainty, we shall wave it ; as well as the Opinion of a third Sort, who affirm that God, who created all Things, gave Life to all his Creatures ; and that the Ebbing and Flowing of the Sea is no more but the Breathing of the Earth, which seems to me a very odd Fancy, and not worth inserting, had it not been in this Collection of the various Opinions of the Learned upon this Subject. I shall amongst the rest, deliver mine own Opinion in the Matter ; and although I do not think my self able infallibly to give a definitive Sentence in the Case, yet I shall endeavour to prove it to be consistent with the Observation and Experience

perience of our Mariners, and shall answer what Objections can easily be made against it.

It is evident to all that own the Rotundity of the Earth, (a Thing generally out of Controversy among the Learned) that there is a Principle of Gravitation towards the Center of the Earth, and that this attractive Influence is diffused to all Beings whatsoever within the Orb thereof; and hence it is, that we who inhabit the Earth find no such Thing as an upper Side and an under Side of the Earth, but in all Parts of the Superficies thereof we find a like Natural Tendency towards the Center thereof, as is evident by the Experience of those that have sail'd about the World, and yet in their so far different (if not diametrically opposite) Places, that they have sail'd to, have found themselves, and every particular Thing, to have the same pressing Inclination towards the Center of the Earth, which seemed to them to be downwards, as well as it doth to us. Now if we grant the Earth this strong Principle of Gravitation, Inclination, or Attraction towards its Center, which Reason and common Experience proves; we have Reason from thence to believe, that the other Bodies, as the Sun and Moon, have the same Principles of Gravitation towards their Centers, (which may be proved by some Reasons, which, to insert here, would be too great a Digression from the present Subject) which being granted, I suppose the Ebbing and Flowing of the Sea to be occasion'd by the Attraction of the Sun and Moon (especially the Moon being a secondary Planet, which moves far nearer the Earth, and respects it for her Center) the Strength of which Attraction, although it cannot have any Influence upon the solid Part of the Earth, yet the Water being a fluid Substance, is more easily affected with this attracting Power, and by Vertue thereof (while the Earth retains its round Form) the Water is gently suck'd and drawn into an oval Form, by reason of its inclining

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Tendency towards those attractive Bodies, thereby causing High-Water where the Ends of the Oval is, and consequently Low-Water at the Middle of the Oval, as may be demonstrated thus: Suppose two Hoops made of any flexible Substance, as Wood, or fine Steel, &c. of equal Dimensions, and laid directly one upon the other; and then, if from opposite Points the uppermost were extended into an oval Form, it is evident, that as the extended Part or End of the Oval is drawn without the round Hoop, the two Sides, or Middle of the Oval, will be contracted and pulled within it; and still, as the transverse Diameter of the Oval were extended and augmented, the Conjugate, or shortest Diameter, will be contracted and diminished; which plainly demonstrates how the Water, when by an attractive Power it is drawn above its mean Elevation, at the End of the Oval, it must needs be depressed below its usual Position at the two Places, a Quarter distant from these two opposite Points, which Elevation and Depression is the Occasion of High and Low-Water, which happens at (near) six Hours Distance, between High and Low-Water, and confirms the Truth hereof, which is also evident by the following Reasons.

First, Because the Motion of the Tides generally follows, and is governed by the Motion of the Moon; so that the Moon being upon one and the same Point of the Compass, makes High-Water at any particular Place, at one and the same Time, (unless accelerated, or retarded, by Winds, Land-floods, or the like) by which it seems very probable, that the Moon is the principal Agent in this regular Motion of the Sea; and if so, then nothing more likely than that the Influence of her attractive Power drawing the flexible Substance of Water into an elliptical or oval Form, as before asserted, is the Cause thereof.

But Secondly, It is observed by all, that the Spring Tides, (*viz.* at the New and Full Moon) are great-

er than the Neap-Tides, (which are at the first and last Quarters) by which it seems evident, that although, as I said in the last Paragraph, that the Moon is the principal moving Cause of the Tides, yet the Sun having also the like attracting Power, hath an Influence upon the Water also, although not so great as that of the Moon, (because the Moon is much nearer the Earth, and is a secondary Planet, respecting the Earth for her Center.) and therefore, when the Sun and Moon are in Conjunction (as at the New Moon) or in Opposition, (as at the Full Moon) then the Tides are greatest; because the attractive Influence of the Sun is added to that of the Moon, and both raise the Water at one and the same Place, making the Spring-Tides. But at the Quarters, *viz.* when the Sun and Moon are about 90 Degrees, or a Quarter of the Zodiac distant, then the attractive Influence of the Sun rather impairs that of the Moon; the one raising the Water where the other depresses it; so that although, for Reasons before given, the Influence of the Moon's Attraction upon the Water is greater than that of the Sun, and therefore the Tides follow the Motion of the Moon, and not of the Sun, yet their contrary Influences lessen the greater Influence, *viz.* that of the Moon: which is the Cause of the Neap-Tides: and this may also be illustrated thus; Suppose a Hoop of Steel, or any flexible Metal, be fastned to any Place, if a Man with a Rope fixed to one Side thereof should pull with all his Strength at the said Rope, it would make the Hoop decline into an elliptical or oval Form; but if another Man, though of inferior Strength, should fix a Rope in the same Place where the first was fixed, his Strength added to the first would make the Ring or Hoop yet more elliptical, and would stretch out the transverse Diameter thereof yet longer, in Comparison of the conjugate. But if the first Rope remain fixed as before, and the other, managed by inferior Strength, be removed a Quarter of the Hoop's Distance

Distance from the first, then, although the Ellipsis will in some Measure retain its oval Form, inclining to the stronger Attraction, yet the Power of the contrary Attraction will depress the other, and cause the Hoop to retain a Form at least nearer to a true Circle, than as if the Attraction were all in one Place; and this plainly illustrates the different Attractions, causing different Tides, viz. when the attractive Powers are united, their Influence is greater, causing the Water to be more elliptical, thereby occasioning Spring Tides, as at the New and Full Moons; but when the attractive Powers are separated, as at the first and last Quarter of the Moon, the Influence of the greater is not so apparent, which is at the Neap Tides.

But my third Reason is, Because we see that the Spring Tides at the Equinoxes, viz. in *March* and *September*, are commonly higher Tides than the Spring Tides at the Solstices, viz. in *June* and *December*; the Sun, and also the New and Full Moon, moving in or near the Equinoctial, in a right Aspect to the Earth; whereas their Influence is somewhat impeded at the Solstices, by their more oblique Position to the Earth. All which seems plainly to prove, that as the Tides are regulated and governed by the Motion of the Moon, so her attractive Power, together with that of the Sun, when joined with it, is the original Cause thereof.

Now against what hath been said, there seems two grand Objections to arise; the first is, that if the Tides are governed by the Moon, and if her Attraction be the Cause thereof, her Diurnal Motion being from East to West, it should follow that the Flood-Tides should in all Places set Westwards; but daily Experience proves the contrary; for it sets in some Places South, as upon the Coast of *England*, and in some Places North, as upon the Coast of *Holland*; yea, and in some Places East, as in *St. George's Channel*, which takes against my former Assertion.

A second Objection is, that if the Tides be caused by the Moon's Attraction, it should be High-Water at all Places, when the Moon is upon the Meridian of the Place, or that a North and South Moon should make full Sea in every Place; but the contrary is evident by the Tide-Tables, and by the Experience of all Sailors.

In Answer to the first, *viz.* that the Flood-Tide should set Westward in all Places, (the Answer to which will also partly imply an Answer to the second, *viz.* that it should always be High-Water at any Place, when the Moon is upon the Meridian of the Place) I grant that if the Tides be occasion'd as before asserted, then this regular Motion of the Sea from East to West, must necessarily follow, if this aqueous Globe were equally environ'd with Water, and that the aforesaid Motion of the Sea were not interrupted by the Land; but it is evident, especially where the Sea joins immediately upon the West of any Main Continent, that the Flood cannot set Westward there, because that would be right from the Shore, as for Example, Suppose the whole Land of Europe and Africa were all one Main Continent; and suppose the North Cape of *Finmark*, in about Lat. 71 North, and the South Cape of *Africa*, in about Lat. 34 South, were both under one Meridian, and that this Main Continent were terminated on the West with a straight Coast, lying under the same Meridian that the two extrem Points, the North and South Capes, lie under; now it is plain, that the Tide cannot come from the Eastward upon this West Coast; but if the Tide be caused by this Westerly Motion of the Sea, according to the Motion of the Moon, it must set Westward, about the North and South Parts of the Main Continent, and so proceed from the North Cape Southward, and from the South Cape Northward, along this West Coast; and the Truth of this seems evident also from our common Experience; for we find

that the Flood proceeds from the Northward, along the Coast of *Norway*, and there finding a Passage between *Scotland* and *Norway*, marches along the East Coast of *England*, and hence it is High-Water sooner in *Scotland* than in *England*, and sooner on the Coast of the North Part of *England* than on the South Part; thus it is High-Water at *Aberdeen* in *Scotland*, 45 Min. after Moon's Southing, but at *Tinmouth-Bar*, not till 5 Hours after, and at the *Spurn* 5 Hours and 15 Min. and at *Cromer* 6 Hours, and at *Yarmouth-Beer* 9 Hours, and at *Harwich* 10 Hours, 30 Min. after the Moon's Southing; the Tide, at the same Time being rowling along the West Coast of *Scotland*, and from thence to the West Coast of *Ireland*, the Passage between the North-East Part of *Ireland*, and the South-West Part of *Scotland*, being so narrow, that the Tide finds little Passage; and therefore the East Coast of *Ireland* is supplied by a Tide which sets Southward along the West Coast; and hence the Tide flows Eastward, along the South Coast, and Northward along the East Coast thereof, as is evident by the Time of High-Water observed in the Tide-Table; for upon the Full and Change Days, it is High-Water at *Seyn-Head* at 10 Hours 30 Minutes, from thence in 6 Hours it passes along the West Coast, and butts in upon the South Coast, so that at 4 Hours, 30 Minutes, it is High-Water at *Kingsale*, *Cork* and *Waterford*, and from thence in 45 Minutes more, it passes over to *Milford*, *Lundy*, &c. and at the same time it slides Northwards, along the East Coast of *Ireland*; so that in 3 Hours 45 Min. it flows from *Waterford* to *Dublin*, and in 45 Minutes more to the Isle of *Man*, &c. Thus the general Motion of the Tide to the Southward, having, as by a Branch proceeding from thence, fill'd up all the Vacancy between *England* and *Ireland*, it proceeds still to the Southward, and upon the Full and Change Days, it is High-Water at the Land's End of *England* at 7 Hours 30 Min. and in its unwearied Motion to the

the Southward, it finds a Passage up *St. George's Channel*, and 45 Minutes after High-Water at the Land's End, it is High-Water at *Portland*, and in 3 Hours 45 Min. more, it is got up to the *Isle of Wight*, *Southampton*, and *Portsmouth*, being High-Water at the same Time on the other Side of the Channel, upon the Coast of *France*, about *Guernsey* and *Jersey*, and so proceeds slowly along the Coast of *France* and *Holland*, still to the Northward, being supplied by a Tide up the Channel; and this (to follow it no further) may sufficiently prove, that the General and Original Motion of the Tide Westwards occasions its Motion to the Southward, along the Coast of *Norway*, and consequently all its compounded Motions and Branchings into the *Irish Sea*, the Channel, &c. And it is very evident, that although the Tide, if not interrupted, should be at the Height where the Moon is upon the Meridian; yet it finding so many whirling Motions to and fro, between the Lands, the Moon, at the same Time, keeping her straight and uninterrupted Motion to the Westward, all the Time that those irregular Vacuities are filling up, it is plain, that the Moon must needs be past far from the Meridian before it can be High-Water at some of those Places; and yet the Tide occasion'd as before asserted; which I think will sufficiently answer the two Objections before mention'd, and prove this Hypothesis to be very consistent with Reason its self, and the Experience of all Observers.

Now if any Body will still insist further upon what I hinted upon before, viz. That the Tide is occasion'd by a Confluence of Water arising at the *Maelstream*, or Navel of the Sea, and proceeding from thence, &c. and for Confirmation thereof, will acknowledge, that they have seen and observed this regular Rising and Sinking of the Water (before spoken of) at that Place; I answer, I can easily approve of this Opinion, without denying mine own hitherto asserted; for they are very easily reconcilable; for it is possible,

possible, and very probable, that this Ebbing and Flowing, at the Mael-stream, may be occasion'd by some subterraneous Cavern, whereby this Place hath some Communication with the Eastern Seas, and is supplied from thence ; which being granted, it will follow, that while the Tide (whose general Motion is Westwards) is interrupted by the Continent of Norway, &c. and thereby is forced to find a Way about the North Cape ; yet by the Way, finding this Passage under Ground, and the Tide, by Vertue of the Moon's Attraction, inclining that Way, there may be supposed to be so much Water convey'd that Way as that obscure Passage can contain, though far short of so much as to occasion that Flowing and Ebbing that is observed : and this being granted, it is evident, that this Rising and Falling at the Mael-stream, must needs keep Time with the Motion of the Moon, and of the rest of the Tide ; because it proceeds from the same Original, and is a small Branch thereof ; and this we may see illustrated by our common Rivers, whose Natural Motion, when interrupted by Banks, or other Impediments, causeth the main Body of the Water to find a Passage some other Way ; yet if, at the same Time, any small Holes be found in the said Banks, there will always so much Water pass thereby as the said Holes can contain ; tho' the main Body of Water is forced another Way : Hence, from what hath been said, it is plain, that this small Flood and Ebb observed at the Mael-stream, must needs have the same regular Motion with the rest of the Tide, which I suppose has at first occasioned, and since seemed to confirm that Opinion, that the Tide proceeds only from thence.

To what hath been said I shall only add, that this that I have here asserted seems yet to be further confirm'd by our Observations abroad ; for it is observed, that there is little or no Tide at the *Straits of Gibraltar*, nor upon the Coast of *Guinea* ; nor can it be expected, according

according to this Hypothesis ; for if the Tide comes from the Northward, it may be supposed, that by that Time that it hath passed so far along, and having so many Vacancies to fill up, as the *German Ocean*, the *Irish Sea*, *St. George's Channel*, the *Bay of Biscay*, &c. its Power must be very much impair'd, if not totally exhausted, before it comes so far as the Coast of *Africa* before mentioned.

Now it may be question'd, what is the Reason that there is little or no Tide in the *Baltick Sea*, seeing there are strong Tides almost on every Side of it, viz. upon the Coast of *Norway*, on the North of it, on the Coast of *Holland* on the South, and on the Coast of *England* on the West of it, &c.

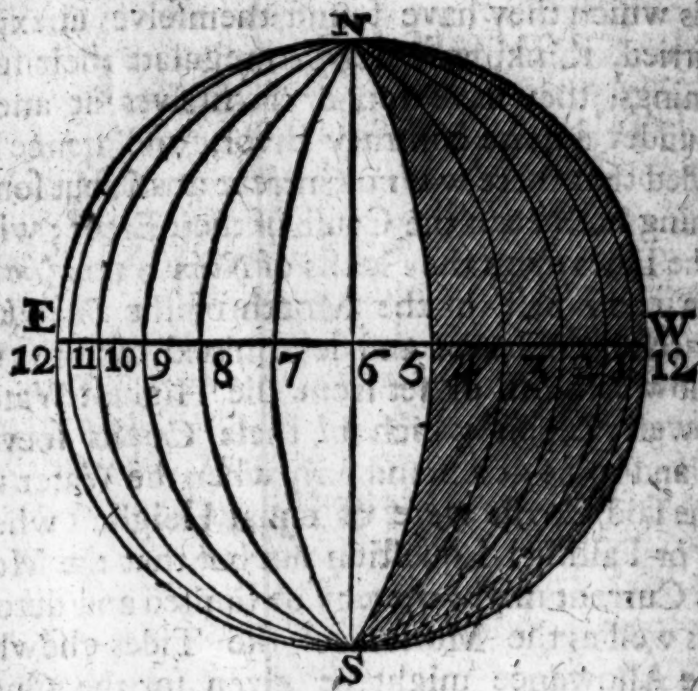
I answer, It is hard absolutely to determine what is the Cause thereof ; but I shall lay down some Conjectures, which may conduce very much that Way ; for if it was High-Water at the *Naze* and Coast of *Norway* at the same Time that it is High-Water upon the Coast of *Futland* Southward from the *Baltick Sea*, it must needs force a Tide into the *Baltick Sea*, as well as a High-Water upon any Coast forces a Tide up the Inland Rivers there ; but this cannot reasonably be expected, if we consider, that the Tide along the Coast of *France*, *Holland*, and *Futland*, proceeds from *St. George's Channel*, and comes from thence Northwards, along the said Coasts of *Holland*, &c. but the Tide upon the Coast of *Norway* sets to the Southward, as hath been largely proved, the two Tides both terminating at the Mouth of the *Baltick Sea* ; hence it is very probable, that it may be High-Water upon the Coast of *Futland*, when it may perhaps be Low-Water, or some intermediate Tide, at the *Naze*, or South Coast of *Norway* ; and if so, it cannot force a Tide into the *Baltick Sea*, but rather a sucking Current, or Inclination of the Sea from that Place on one Side of the Mouth of the *Baltick Sea* where it is High-Water, to that Coast on the other Side where it is Low-Water ; and

and hence it will necessarily follow, that this Current must set sometimes one Way, and sometimes another. And this may be assign'd as a Reason why many have found themselves deceived in their Reckonings, when intending to make the *Naze*, or other Lands thereabouts; and when they have imputed their Mistake to a Current setting towards that Point of the Compass towards which they have found themselves unexpectedly carried, thinking thereby to regulate their future Reckonings, they have found themselves at another Time, under a quite contrary Error, and hence have concluded that there was no Current at all, but some other Thing hath been the Cause of their Error; whereas, if the Tides upon the Coasts of *Norway* and *Futland*, viz. on each Side of the Mouth of the *Baltick* Sea, were carefully observed and determin'd, and the Current allow'd to run or set from the Highest Water to the Lowest, (upon which of these Coasts soever it were) and to be at a Stand only when the Water upon both the said Coasts were of equal Height (whether Rising or Falling) I question not but that the Motion of this Current might thereby be limited and determin'd, as well as the Motion of the Tides elsewhere, and due Allowance might be given for the Current there, as well as for the Ebbs and Floods in other Places, to the great Satisfaction and Advantage of those that use the *East-Country* Trade.

This Motion of the Tide thus granted, I shall next shew how to find the Time of the Moon's Southing, and (with a little Application) the Time of High-Water by a Sight of the Moon, at any Time of the Day.

How

How to know the Time of the Moon's Coming to South, only by a Sight of the Moon, at any Time of the Day or Night.



IT is commonly known, that the New Moon being in Conjunction with the Sun, souths at Noon, and the Full Moon being opposite to the Sun, comes to the South at Mid-night; and at the Quarters, when she is just half full, *viz.* to the Line N. 6 S, which crosses the Figure directly in the Middle, then she is South at 6 a-Clock, and if the light Half be on the West Side, N.W.S, and she half full, she souths at 6 in the Evening, as at the first Quarter; but if the light Half be on the East Side, N.E.S, she souths at 6 in the Morning, which granted, the Moon's Coming to the South upon any other Phasis, or at any intermediate Age, may be easily gather'd from the Figure above, observing this

This General Rule; When you see the Moon at any Time of the Day or Night, observe as near as you can, how much of the Moon is light, whether on the East or West Side, and compare it as near as you can with the Figure, considering to which Line in the Figure you suppose the Light Part will reach, and observe what Figure is upon that Line, for that is the Hour at which the Moon will come to the Meridian that Day or Night; as for Example.

Suppose I observe the Moon, and find her somewhat more than half light on the East Side, so that comparing the Moon with the Figure, I suppose the Light Part to appear like the Light Part of the Figure; then I observe to what Number the Light Part reaches, and I observe it reaches to the Number 5; and hence I conclude, that the Moon comes to the South about 5 o'Clock; and because the Light Part is on the East Side, I conclude it is at 5 in the Morning she will be upon the Meridian.

Again, Suppose I see her in the Evening, and the Light Part on the West Side, as near as I can compute, to be like the darker Part of the Figure, towards the right Hand, then observing how far the light Part extends, I see it comes to the Figure 5, and because the light Part is on the West Side, I conclude she will be South at 5 in the Evening, &c.

And thus as you observe the Moon two or three Days after the Change to appear in the West in the Evening, with a very little Light on the West Side, which by Computation may be supposed to come as far over the Moon's Body as the Figure 3, I conclude she has been upon the South that Afternoon about 3 o'Clock, and the next Night you will observe the Light to increase, and come towards the Figure 4, I conclude she was South that Afternoon between 3 and 4, or near 4, and then perhaps 5 or 6 Days after, I observe the Light Part increased beyond half the Body of the Moon, as far as the Arch N. 8. S. I conclude
from

from hence, that the Moon is South about 8 of the Night; and altho' this Method is not sufficient to find the Moon's Southing exactly to a Minute, yet it is of sufficient Exactness for reckoning the Tides, where Quarter of an Hour, or Half an Hour, make no material Error, it being generally impossible to predict the Tides to the absolute Exactness of a Minute, although you had the Moon's Southing exactly, because Winds, or Land Floods, &c. may alter the Tide, and few that have the Charge of a Ship will trust to the first or last Scruple of the Tide, for going into an Harbour, or coming out, but will endeavour, if possible, to have the best of the Tide, and to be ready for it against it come, whether Ebb or Flood.

The Moon's Southing being thus found, the next Thing is to shew how thereby to find the Time of High-Water, at any known Port, and for an Help thereunto, I have inserted a Tide Table, in an Alphabetical Order, in which you need but find the Name of the Port, at which you would know the Time of High-Water, and against it you have a Number of Hours and Minutes, which added to the Time of the Moon's Southing, gives the Time of High-Water at that Place that Day; as for Example.

Suppose I were lying before *Tinmouth-bar*, waiting for half Flood to go in, I happen to see the Moon in the Morning, and I observe the East Side of the Moon to be light, like the light Part of the Figure before spoken of, *viz.* It is by Computation so much above half the Body of the Moon, that the whole light Part reacheth to the Figure 5; and because the Light is on the East Side, I conclude she is South at 5 in the Morning, then I look in the Tide-Table, in the Letter T, and find *Tinmouth*, and against it I find 3 Hours 0 Minutes, which added to 5, the Time of the Moon's Southing, the Sum, which is 8 Hours 0 Min. is the Time of High-Water at *Tinmouth-bar*; so that I find I may go in about 5, 6, or 7 a Clock, with the Flood Tide,

Tide, according to the Draught of Water that my Ship requires.

Now it is not necessary, that you should always have this Book or Figure about with you, for you may, with a very little Practice, get the Nature and Reason of it imprinted in your Memory, always remembering that the New Moon being with the Sun souths at Noon, and the Full Moon being opposite to the Sun, souths at Midnight. The Moon in the first Quarter, is South at 6 in the Evening, and at the last Quarter is South at 6 in the Morning. All the intermediate Times of her Age may be easily computed, according to the Figure, exact enough for finding the Time of High-Water, at any Port mention'd in the Tide Table.

If any will object, that what hath been said serves only for finding the Time of High-Water, at Places mentioned in the Tide-Table, but no where else; I answer, that by this Way of finding the Moon's Southing, and consequently the Time of High-Water at any Port mention'd in the Table, together with a right Apprehension of the General Motion of the Tides, as you have it sufficiently described and illustrated, in the Beginning of this Section, you may be able to give a very good Account of the Tide both at those Places inserted in the Table, and at those that are not, provided you know but upon what Coast the Places are, and how situate from some known Place express'd in the Table, and whether they are upon the Sea-Coast, or up some River, and the like; as for instance, Suppose coming from the West of *England*, up the Channel, intending for *Bulloigne*, and not having a Tide-Table that hath the Port of *Bulloigne* expressed in it, I am at a Loss to know how the Tide falls, (supposing it at the New Moon) Now suppose in my Tide-Table, I find *Diepe* and *Dunkirk* (Ports on each Side of *Bulloigne*) and upon Examination I find it is High-Water at *Diepe*, on the Full and Change Days, at 9 Hours,

45 Min. Again, I find it is High-Water at *Dunkirk* the same Days at 12 a Clock; now I conclude that *Bulloigne* lying betwixt these two Ports, hath also High-Water between these two Times, and not long after High-Water at *Diepe*, as if you look in the Table, you will find it is High-Water at 10 Hours 20 Min. at the Full and Change.

In like manner, if you observe the General Motion of the Tide to the Southward, along the East Coast of *England*, and to the Eastward, up the Channel, &c. you may, by knowing the Time of High-Water at any Port, very easily compute the Flowing and Ebbing of the Tide at any adjacent Port, and with Allowance for deep Bays, or inland Rivers, you may very nearly determine the Time of High-Water at any desired Port.

 *Note*, What is here said of the Tides is meant as to their General Motion, the half Tides, quarter Tides, and Currents, being a Thing that depends so much upon Experience, that it is in vain to treat of them here.

A large Tide-Table after a new Method.

A	H. M.		H. M.
A Berdeen	0—45	Brovage without	3—45
A St. Andrews	2—15	Baltimore	4—30
Amsterdam	3—00	Bree-Sound	4—30
Armentiers	3—00	Blackney	6—0
Abroth	5—15	Bristol	6—0
Antwerp	6—00	Bristol Key	6—45
Archangell	6—00	Bridgwater	7—30
Abermorich	6—00	Cape Blanco	9—45
Amazons River in		Bulloign	10—30
South America	6—00		
Aldbrough	9—45		
		C	H. M.
		Cape Cautin in	
B	H. M.	Barbary	0—0
B Each	0—0	Calice without	1—30
B Bojador in		Camfere	1—30
Barbary	0—0	Coquet	3—0
Blacktail Beacon	0—15	Cork in Ireland	4—30
Blackness	1—30	Cape Clear in Ire-	
Bell Isle	1—30	land	4—30
Berwick	1—30	Caldy	5—15
Bluet without	2—15	Carnarven Bay	5—15
Britain South Coast	3—0	Cromer	6—0
Biscay Coast	3—0	Caskets without	8—15
Bordeaux River	3—0	Cape Sierre-lion in	
Buchanefs	3—0	Guiny	8—15
Bona Esperance	3—0	Chambernefs	9—45
Brest	3—45	Cows	10—30
Bals without	3—45	Caen in the Fofs	10—30
Bridlington	3—45	Calice Road	10—30
Bordeaux River		Calshot	11—15
within	3—45		
		Q	Dunkirk

D	H. M.		H. M.
Dunkirk	0—0	Falmouth	4—30
Dover Port	0—0	Foy	5—15
Port Desire in A-		Foulness	6—45
merica	0—0	Friesland Coast	7—30
Downs	1—30	Florida in Carolina	7—30
Dundee	2—15	Foreland North	
Denby	2—15	& South	9—45
Dort	3—0		
Dunbar	4—30		
Dungarven	4—30	G	H. M.
Dartmouth	5—15	Gibraltar Road	0—0
St. David's Head	6—0	Guernsey	0—45
Dublin in Ireland	8—15	Gooree	1—30
Diep	9—45	Gravesend	1—30
Dunwich	9—45	Gascoin	3—0
Dover	10—30	Groy	3—0
		Gorend	11—15
E	H. M.	H	H. M.
Eider	0—0	Ever	0—0
Elve	0—0	Hern	0—0
Enchuyfen	0—0	Holy Island	1—30
Edam	1—30	Hartlepool	3—0
Edinburgh	4—30	Humber without	4—30
Egmon	4—30	Hull	6—0
Exwater	7—30	Hamborough	6—0
Entrance of the		Hague	8—15
Fmes	7—30	Harwich	10—30
		St. Hellens	10—30
F	H. M.	I	H. M.
Fushing	0—45	Jutland Isles	0—0
Finmark Coast	1—30	Ireland W. Coast	3—0
Fountnay without	2—15	Ireland South Coast	5—15
Flamborough head	3—0	John de Luce	10—30
Fair Isle	3—0		
Frith	4—30		

		N	H. M.
K	Entish Knock	0—0	Newport in the
	Killians	3—0	Isle-of-wight
	Kingfale in Ireland	4—30	Nore West End
	Kilduyn	7—30	North C. Maggero
			Nantz River without
			Newcastle
L	Isbon	2—15	St. Nicholas in
	St. Lucas	2—15	Russia
	London	3—0	Needles
	Leith	4—30	Normandy Coast
	Lawreness	4—30	
Lyn without	Lundey	5—15	O
	Lyn	6—0	Orkneys
	Lanion	6—45	Orwell
	Landsend	7—30	Orfordness
	Lam Bay	8—15	
Leystaff	Lenow	9—45	P
			Portsmouth
			Poictou South
			Coast
			Pens
M	Aze within	0—45	Porthus
	Malden	0—45	Portugal Coast
	St. Mark	2—15	Plymouth
	St. Matthew Point	3—45	St. Powls
	Mount's Bay	4—20	Podese milk in Russia
Milford	Moonless	5—15	Portland
	St. Maloes	5—15	Peterport
	Magnes Sound	8—15	Picardy Coast
	Macknel's Castle	8—15	
	Isle-of-Man	9—0	Q
Marget Road		11—15	Uinborough
			Quebeck in
			Canada
			Q 2
			R

R	H. M.		H. M.
R Ebdan	0—45	Torbay	5—15
Rocheſter	0—45	Texell	7—30
Rumney	1—30		
Ramkins	1—30		
Rotterdam	3—0	U	H. M.
Rovain	3—45	U Rk	0—0
Rochell <i>without</i>	3—45	Uſe	3—0
Roan River <i>witbin</i>	3—45	Uſhant <i>without</i>	6—0
Ramſey	5—15		
Rye	11—15		
Rhodes	11—15		
		W	H. M.
		I Sle-of-Wight	0—0
		Wincheſſea	0—45
		Weilands	1—30
		Whitby	3—0
		Waterford in Ire-	
		land	4—30
		Weymouth	6—0
		Weles	6—0
		Weymouth Key	6—45
		Wieringham	7—0
		Winterton	9—0
		Y	H. M.
		Y Oughall in	
		Ireland	4—30
		Yarmouth Road	8—15
		Yarmouth Peer	9—0
		Yarmouth Town	9—45
		Yarne	6—45
		Z	H. M.
		Z Ealand Coaſt	1—30

S	H. M.
S Heerneſs	0—0
Southampton	0—0
Spits	0—0
Shotland	3—0
Silly	3—45
Scarborough	3—45
Sound	3—45
Severn	4—30
Stockton	5—15
Spurn	5—15
Start	6—45
Seyn-Head	10—30
Senegall	10—30

Sect. 5. *The Use of the foregoing Table.* 229

The Use of this Tide-Table is the same as in other Tide-Tables, for when you desire to know the Time of High-Water at any Place mentioned in the Table, you need but look in the Letter that the Name of the Place begins with, and there having found the Place you want, see what Hour and Minute stands against it, which being added to the Hour and Minute of the Moon's coming to South, the Sum (abating Twelve Hours, if it exceeds) is the Time of High-Water at the Place proposed that Day. — *Example*; I desire to know what Time it will be High-Water at Harwich, March the First, 1714. I look in the Letter H, and find Harwich, and against it 10—30, which added to the Moon's Southing that Day, the Sum is 19 18, from which cast away 12, the Remainder is the Time of High-Water: Of which see more in the Explanation of the following Table of the Moon's Changing.

A Table of the Moon's Changing for 15 Years.

Years	January		Febru.		March		April		May		June	
	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.
1714	5	4 m	3	2 a	4	12 a	3	9 m	2	6 a	1	4 m
1715	24	4 m	22	2 a	23	11 a	22	9 m	21	5 a	19	2 m
1716	13	3 a	12	6 n	12	4 a	11	3 m	10	9 a	8	5 a
1717	1	6 a	None		2	4 n	30	2 m	29	10 m	27	5 a
1718	31	0 a	None		0	2 n	30	2 m	29	10 m	27	5 a
1718	30	1 a	19	7 n	20	11 a	19	2 a	19	1 m	17	10 m
1719	9	1 a	8	7 n	10	1 m	8	6 a	8	9 m	6	10 a
1720	28	10 m	27	2 a	27	6 a	26	11 m	26	2 m	24	3 a
1721	16	8 a	15	9 a	16	10 a	15	0 a	15	3 m	13	6 a
1722	6	11 m	4	9 a	6	8 m	4	7 a	4	6 m	2	8 a
1723	25	2 m	23	11 a	25	9 m	23	7 a	23	4 m	21	2 a
1724	15	4 m	13	4 a	14	3 m	12	10 m	11	5 a	10	1 m
1725	3	11 m	2	3 n	3	4 a	2	2 m	1	10 m	28	12 a
1726	22	7 m	20	12 a	22	2 a	21	2 m	20	11 m	18	6 a
1727	11	7 m	10	1 n	11	8 a	10	11 m	9	12 a	8	9 m
1728	30	2 m	28	8 a	29	1 a	28	5 m	27	7 a	26	6 m

The Use of the Table of the *Moon's Changing* is so easy, that it needs little Explanation; for find the Year in the first Column to the Left-Hand, and the Month at the Top, and in the common Angle you have the Day and Hour of the Moon's Changing that Month.

Note, M. stands for *Morning*; A. for *Afternoon*.
Example; I desire to know the Moon's Changing in *June*, 1720: Find 1720 in the Left-Hand Column, and against it, under *June*, you find 24 3 a, that is the Moon changes *June* 24 at 3 in the *Afternoon*; and where you find two Numbers against one Year, and under one Month, the Moon changes twice that Month; as against 1725, under *May*, you find

$\left. \begin{array}{l} 1 \quad 10 m \\ 30 \quad 5 a \end{array} \right\}$ that is, the Moon changes twice in

May

Years	July		August		Sept.		October		Nov.		Dec.	
	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.	D.	H.
1714	30	7 m	28	11 a	27	4 a	27	9 m	26	1 n	25	4 a
1715	19	0 a	17	12 a	16	3 m	16	9 m	15	3 n	14	10 a
1716	7	12 a	6	9 m	4	8 a	4	10 m	3	3 n	2	10 a
1717	25	12 a	25	8 m	23	6 a	23	7 m	21	11 a	21	6 a
1718	16	5 a	15	1 m	13	8 m	12	6 a	11	6 n	10	8 a
1719	6	8 m	4	5 a	3	2 n	2	11 n	10	7 n	29	8 a
1720	24	5 m	22	3 a	21	7 m	20	1 a	18	10 a	18	8 m
1721	13	9 m	11	11 a	10	1 a	10	3 m	8	2 a	8	1 m
1722	2	10 m	1	2 n	29	9 m	28	12 a	27	4 a	27	3 m
1723	21	2 m	19	5 a	18	10 m	18	3 m	16	9 a	16	2 a
1724	9	10 m	7	9 a	6	11 m	6	3 m	4	11 a	4	5 a
1725	28	8 m	26	6 a	25	7 m	24	11 a	23	5 a	23	0 a
1726	17	12 a	16	8 m	14	5 a	14	4 m	12	6 a	12	0 a
1727	7	5 a	6	1 m	4	8 n	3	6 a	2	5 n	1	5 a
1728	25	4 a	24	1 m	22	10 m	21	7 a	20	5 n	19	5 a

May 1725, viz the First Day at 10 in the Morning, and the Thirtieth Day at 5 in the Afternoon, and so in the rest: From hence you may easily find the Moon's Age, and her Southing, and consequently the Time of High Water at any Port mentioned in the Tide-Table.

Example: I would know what Time it was High Water at *Harwich*, *March 2*, 1714. I look for the New Moon next before, and I find it was *February 3*, and hence the Moon on *March* the 1st is 26 Days old, which multiplied by 4, and the Product 104 divided by 5, the Quotient is 20 $\frac{4}{5}$ for the Moon's Southing, or 20 Hours, 48 Minutes after Noon, or 8 Hours, 48 Minutes *March 2* in the Morning, to which add 10 b. 30 m the Hours and Minutes standing against *Harwich* in the Tide-Table, the Sum is 19 Hours, 18 Minutes, from which cast 12, the Remainder

Q 4

7

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7 Hours, 18 Minutes, is the Time of High-Water
Harwich required.

Note. If the Moon be less than 15 Days Old, look for her Age the Day proposed to find her Southings but if more than 15 Days old, (as in this Example) look for her Age the Day before (or abate 1 from her Age the Day proposed) and then work as before, because when the Moon is above 15 Days old, she comes to *South* above 12 Hours Afternoon, which may more properly be called next Morning, and consequently you abate 1 from her Age found when above 15 Days old, the Southing found from thence is properly her Southing for the Morning of the Day proposed, &c.

SECT. VI.

How to keep a Reckoning.

HAVING thus learned to find the Variation, and to work an Observation, and also to reckon your Tides, with other Things necessary to be known, and having, as Master, Mate, or Pilot of a Ship, taken you

your Charge for any Voyage, and having your Log-Line, Glasses, and other Things in Readiness, you must provide a Log-Board ruled as you see in the Margin.

Then having let Sail, and got from the Shore, and out of the Set of the Tide, observe how the Land bears from you that you intend to take your Departure from; and also, as near as you can, compute the Distance you are from it, and then that Course and Distance prick'd off upon your Chart gives the true Place of your Ship when you begin your Reckoning.

	1	2	3	4	5	6	7	8	9	10	11	12
2												
4												
6												
8												
10												
12												
2												
4												
6												
8												
10												
12												

This done, having settled your Watches, and ordered a Man to the Helm for two Hours, let him observe carefully what Course he steers by the Compass, or if he be ordered to steer upon any given Course, let him take care to mind it, and at the End of two Hours let the Mate heave the Log, having one attending him with the $\frac{1}{2}$ Minute Glas, let the Mate over-haul off the line, (having first cast the Log with 3 or 4 fakes of line into the Sea) till the Red Rag come to his hand, and at that instant cry *Turn*; the Man with the Glas, just upon that Word, as the red Rag goes away, turning the Glas, and watching diligently: When the half minute Glas is just out, the Man

Man that holds the Glafs, cries *Stop*; whereupon the Mate stops, and hauls in the line, observing exactly how many Knots, half Knots, and Fathoms are gone out, and sets it down upon the Log-board, against the Hour at which the Log was heav'd; and thus proceed every two Hours all the 24 hours, and then the Log-board will be full the next day at noon.

Then having a Log-book Ruled every Page, like the Log-board, with the Day of the Month at the top, take off the Log into your Book, and rub out the Chalks upon the Board, so is the Board ready for the next day. I shall Instance in the Voyage from *Flamborough-Head*, Latitude 54 8 North, and 16 26 to the Naze of *Norway*, Lat. 58 North, and Longitude 21 0, set Sail *August* 25, at noon, and running that day as by the Log on the other Side.

3. *Note*, Any 24 hours Log, from Noon to Noon, is dated by the Day upon which it ends, and not upon the Day upon which it begins; then if we set Sail *Aug.* 24, that 24 hours Log must be called *August* the 25th, &c.

The Ship having run every two Hours as you see in the Log on the other side, add up all the Knots together, the Sum 47 being doubled (because you Heave the Log but every two hours) is 94, to which add the 4 half Knots, which in this case are accounted as 4 whole Knots, because they are also doubled: The Sum 98 miles is the Distance run that Day. — The Course is N. E. but because there is a Point Variation, West, the true Course is N. E. by N. therefore set down under the Log — Made good 98 Miles N. E. by N.

right. Then find in the Traverse Table your Northing and Easting, for that Course and Distance, and set it in the blank Space on the left hand as you see done.

The Northing 81, 5 Miles or Minutes added to the Latitude Sail'd from 54 deg. 8 min. the Sum is the Latitude come to 55 d. 29 m (the 5 which is placed after the 81 being but a decimal, or half mile, need not be regarded) which set down also as you see.

For

For the Difference of Longitude you may find it by the Traverse Table, the middle Latitude being 55, Complement 35 being found, and under it in the Column of Departure, find the Departure, or Easting 44 or the nearest to it; and against it, in the Column of Distance, you have 95 min. or 1 d. — 35 m. for the difference of Longitude, which added to the Longitude Sail'd from, because it is East Longitude,

H. K. $\frac{1}{2}$ K. F.				Course Winds		Aug. 25. 1714.
				N. E.	West	
2	3					Variation 1 point West.
						Northing ——— 81. 5.
4	4					Easting ——— 54. 4.
						Lat. come to — 55°. 29'.
6	4	I				Diff. Longitude — 1. 35.
						Long. come to — 18. 1.
8	5					
10	5					
12	5					
2	4	I				
4	4					
6	4					
8	3	I				
10	3	I				
12	3					

Made good 46 Miles North, 6 degrees Westerly.

the Sum 18° = 1 is the Longitude come to; all which set down as you see.

Now

Now to find when your Ship is in the first or last of the Charts before mentioned, which are all made for this Voyage: And first for the first particular Chart; Set off 98 Miles from *A*, upon a N. W. by West Line, it will reach to the Point *a*, the Place of the Ship required; or take the Difference of Latitude made that day 81 5 in one Pair of Compasses, and the Departure or Easting 54 4 in another Pair of Compasses; then with one foot of each pair of Compasses in *A*, run that in which you have the difference of Latitude along the East and West line *AC*, and that pair in which you have the Departure along the North and South line *AB*, the Moveable Points will fall in *a* as before.

To find where the Ship is in the *Mercator's* Chart, take the Latitude in one pair of Compasses thus; let one foot upon the line *q d* in the Latitude come to 55 29, which is at the point *q*, and extend the other to any Parallel, as suppose the line 55 55; then after the same manner take the Longitude in your Compasses, running them Parallel to any North and South line, the meeting of their Moveable Points, viz. at *x*, is the Place of the Ship required. — *Note*, The Place of the Ship at *x*, in the third Chart is found by either of the two Methods by which it is found in the first.

How to keep Account of a Ship's Way upon a Wind.

A Ship is said to Sail upon a Wind, when her Tacks are Aboard, and her Yards sharp Braced, and is commonly supposed to be within six Points of the

the Wind with Lee-way, according to the Sail the carries, viz. *hoop* *slam* *sound* *cl* *st* *slaves*

All Sails set	1 Point	Try under Mainfail
Topfail taken in	2	only. ——— 5
Both Topfails in		Under Mizzen only 6
and a Sea. ——— 3		Lye a Hull, all
Try under Mainfail		Sails Furl'd. ——— 7
and Mizzen. ——— 4		

According to these Allowances of Lee-way, I shall Work the following Examples; nevertheless, in Practice Lee-way must be allow'd according to Judgment, for some Ships make more Lee-way than others, with the same Sail set, &c.

This Example, Aug. 26, hath two Courses, which must be reduced to one by the Rules for working a Traverse by the Traverse Table. ——— The first Course is N. E. by the Compass, but by the Variation allow'd, viz. one Point West, it is N. E. by N. but the Wind being N. N. W. viz. within six Points of the Course, we must allow one Point Lee-way from the Wind, which brings it again to N. E.

For the Distance, add up the first six number of Knots, during which time she lay upon that Course, the Sum 21 doubled, and the two half Knots added, makes in all 44 Miles N. E. for the first Course.

The second Distance by the same Rule, is 39 Miles, the Course by the Compass N. W. but a Point Variation West makes it N. W. by W. and a Point Lee-way, which is also Westerly makes the Course made good to be W. N. W. the Distance 39 miles.

Course	Dist.	North	South	East	West	By Tra-
N. E.	44	31 — I		31 I		verse Sailing
W. N. W.	39	14 —			36 0	as perform'd
		46 0			31 I	by the Ta-
					4 9	ble, you find
						the North-
						ing 46.0 and
						the Westing

4 9, and by Case the sixth of plain Sailing, by the Traverse Table, the Distance made good is 46 Miles North, 6 degrees West; all which set down as in the first Day's work: Then add this Day's Northing to the Northing got before, the Sum 127 5 is the Total Northing. Also Subtract this Westing 4 9 from the Easting got before, the Remainder, 49 5 is the Total

H	K	$\frac{1}{2}$ K	F	Course	Winds.	Aug. 26, 1714.
2	3			N. E.	N.N.W.	Variation 1 Point West
						Northing ——— 45
4	3	I				Westing ——— 4
						Total Northing — 127
6	4					Total Easting — 49
						Latitude come to 56
8	4					Diff. Longitude 0 9
						Long. come to — 17 5
10	3	I				
12	4					
2	3	I		N. W.	N.N.E.	
4	3	I				
6	3					
8	3	I				
10	3					
12	3					

Made good 46 Miles North, 6 Degrees Westerly.

Eastings, both which set down as you see; also by adding 46 Minutes to the last day's Latitude, the Sum 56 15 is the Latitude come to.

The

The Difference of Longitude is 9 min. which, because it is West, it is to be Subtracted from the Longitude the Day before, and the Remainder 17 d. 52. m. is the Longitude come to.

Now to find where the Ship is, upon the first and last Charts, take the Total Northing in one pair of Compasses, and the Total Easting in another pair, and proceed as before from *A*, the place Sail'd from, it shall produce the Point *e*, for the place arrived at: Also in the second, which is a *Mercators* Chart, find the Longitude and Latitude come to by the Method prescribed in the first Day's work, and their Meeting or Intersection is at the Point *e*, the place of the Ship required.

Note, In the first and last Charts you may set off one Course and Distance, by another, as in Traverse, Sailing Geometrical, but I shall not insert that way lest it too much confine the Draught.

How to correct a Reckoning by an Observation.

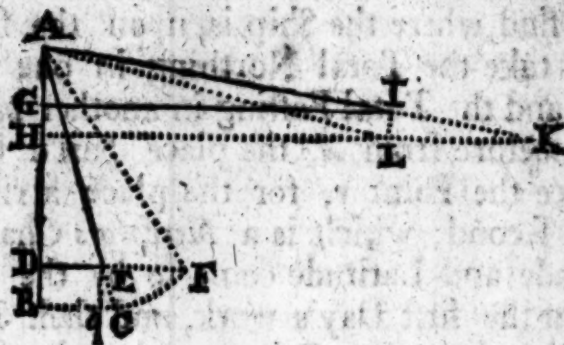
IN the following Day's Work, *August 27*, there is made good 116 Miles; the Course, with Variation allow'd, is N. E. by N. and the rest as you see found by the foregoing Method.

It is needless to give any more Examples of Allow-ing for Leeway, or Variation, the Rule being the same when Leeway is 4, 5, 6, or 7 Points, as when it is but one Point, only minding to allow as much as it is, and the right Way. Thus if a Ship lye *North* with Wind at E. N. E. and 6 Points Leeway, she makes her Way good at W. N. W. &c.

My Reckoning at Noon, *August 27*, brings me into Latitude, 57, 51, but by Observation, which I must prefer before the dead Reckoning: I find I am in Latitude 57, 34. Now to correct the Reckoning by an Observation, observe this general Rule.

If

If your Difference of Latitude be $\left. \begin{array}{l} \text{more} \\ \text{less} \end{array} \right\}$ than the Depart. the Fault is most likely to be in the $\left. \begin{array}{l} \text{Log or Dist.} \\ \text{Co. or Course} \end{array} \right\}$



The Reason of the General Rule above, is evident from the Figure; for suppose a Ship at *A* Sails South Easterly, till by his Reckoning he is at *C*, or in the Latitude of the Parallel *B C*, but by Observation he is in the Parallel of Latitude *D, E, F*: Now if we will suppose his computed Distance *A C* to be right, sweep the Arch *C F* till it cut the Parallel *D F* in *F*, and make *A F* equal to *A C*: now by this means the line *A F* is the line described by the Ship's Motion, whereas we thought it had been the

H	K	^A K	F	Course	Winds	Aug. 27, 1714.
2	3	I		N. E.	West	Variation 1 Point West
4	4					Northing ——— 96. 4.
6	4	I				Easting ——— 64. 4.
8	5					Total Northing — 223. 6.
10	5					Total Easting — 113. 9.
12	5	I				Latitude come to — 57. 51.
2	6					Diff. Longitude — 1. 59. E.
4	6					Longitude come to 19. 51.
6	5	I				Lat. by Observation — 57. 34.
8	4	I				Tot. Easting correct — 105. 2.
10	4	I				Tot. Northing Cor. — 206. 9.
12	4					Long. come to Cor. — 19. 35.

Made good 116 Miles N. E. by N.

the line *A C*; but it is absurd to think that any should be so far mistaken in their Course as to steer from *A* to *F*, when he thought he had been steering from *A* to *C*; and therefore we must impute the Fault to the Distance, supposing that the Mistake lies there, and that when he thought he had steer'd from *A* to *C*, his Reckoning was a-head of the Ship, and that when he should have been at *C* he was only at *E*, the Space *E C* being but a tolerable Mistake in the whole Distance *A C*.

R

But

But in a more Easterly (or Westerly) Course, suppose a Ship sail from *A* till his Course and Distance by Dead Reckoning is represented by the Line *A I* and the Latitude come to by the Parallel *G I*, but by Observation he is in the Parallel of Latitude *H L*. Now if he were supposed to keep a right Account of his Course, and the Fault to be in the Distance, we must continue the Line *A I* till it cut the Parallel *K*, and allow him to be the whole Distance *I K* mistaken in his Account, which is absurd, and therefore impute the Mistake to the Course; and then with one Foot of the Compasses in *A*, with the Extent *A I* describe the Arch *I L*, and draw the Distance *A L* equal to *A I*, and suppose that when he supposed he had sail'd along the Line *A I* he had indeed sail'd along the Line *A L*, the Angle *I A L*, being a much more tolerable Fault in the Course, than the Distance *I K* could be supposed to be in the Distance.

Note, If you sail in a Current you may easily be grossly mistaken, either in Course or Distance; but see that see more at the latter End of this Book.

Now in this Example the observed Latitude *47* differs from the Latitude by Reckoning the Quantity of 17 Miles or Minutes, and because the Total Northing is more than the Total Easting, I impute the Fault to the Distance by the Log, and then it is corrected by this Proportion.

As the Total Northing 223. 6, to the Total Easting 113. 9, so the Error in the Northing 17 to the Error in the Easting 8. 7 nearest.

$$\begin{array}{r}
 113.9 \\
 17 \quad 223.6 \quad \left(\begin{array}{l} 1936.3 \\ 1475 \end{array} \right) \left(8 \frac{1475}{2236} \right) \text{ or } 8.7 \text{ Miles nearest, to be} \\
 \hline
 797.3 \\
 1139 \\
 \hline
 1936.3
 \end{array}$$

subtracted from the Total Easting 113.9 the Remainder 105. 2 is the total Easting Correct.

The Reason of this Proportion is evident from the Diagram; for in the Triangle ABC , as the Total Northing by reckoning AB , to the Total Easting by reckoning BC , so the Error in the Northing to the Error in the Easting qc ; for the Sides of the Triangles ABC , and Eqc , are equal; by *Eucl. 6. Prop. 4.*

Then to correct the Longitude; As the proper Difference between the Latitude by Reckoning, and the Latitude by Observation, to the Meridional Difference between the same two Latitudes, so the Error in Departure to the Error in Longitude, that is, as 17 to 8.7 to the Error in Longitude.

32 8.7 — 22.4 256 — 278.4	17) 278 1c8 ..6	(16 Minutes, (rejecting the Fraction, being but a Fraction of a Minute) to be subtracted from the Longitude by Dead Reckoning, the Remainder 19 35 is the true Longitude Correct by Observation.
--	--------------------------------	---

But in case your Course be far Easterly or Westerly, and the Observed Latitude differs from that found by the dead Reckoning, it is best to correct only the Latitude, reducing it to the observed Latitude, and not to meddle at all with the Departure or Difference of Longitude; because the Error is so small, in the foregoing Figure the true Departure HL differs so little from the Departure found by dead reckoning GI , that it is not worth the while to correct it, unless you have some certain Observation of Longitude to correct it by.

When you have thus corrected your Latitude, Departure, and Difference of Longitude for this Day at Noon, as here Aug. 27, and proceed to the next Day's Work, add the next Day's Northing to the Northing correct this Day, to find the Total Northing next Day,

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Day, and not to the Northing found by dead Reckoning; and do the same also with Departure and Difference of Longitude, not regarding that found Reckoning, and so proceed as before; and when you get another Observation to correct your Reckoning by, add up only the Northing and Easting made good since the last Observation, and not of the whole Voyage, and so correct again according to this Example.

Now for setting off that Day's Work *Aug. 27* upon each Chart, the Method is to be used that was before directed to, and the Point *Z* in each Chart, to represent the Place of the Ship *August. 27, Noon*.

Now if you desire to know the Course and Distance from the Ship to the Naze of *Norway*, it may be done easily and exactly upon the two last Charts, and chiefly upon the last of all the three; for in it you need but set one Foot of the Compasses in the Point *Z*, where the Ship is, and the other Foot in the Point *B*, the Naze of *Norway*; that Extent applyed to the graduated Line *B D*, accounting every Degree Miles, and every small Division 10 Miles, gives the true Distance required 53 Miles.

In the second Chart, which is according to *Wright's Projection*, commonly call'd *Mercator's*, if you use the Method which you have there prescribed, finding the Distance of any two Places upon a *Mercator's Chart* Geometrically, you will find it exactly agreeing with the former, viz. 53 Miles.

For finding the Course, the Method is the same in both; for the Rumbs are right Lines, equally divided or at equal Distances in both Charts; therefore in your Charts have the Rumbs upon them, Observe which Rumb a Line drawn from the Ship to the Port would be parallel to, for that is the Course required; but if you would still be more exact, you may find the true Course and Distance from the Ship to the Port, by Case the Sixth of *Mercator's Sailing*

Trigonometric

trigonometrical, thus (having both Latitudes and Longitude given.)

	Lat.	Long.
The Ship when cor. by Observ. is in	57. 34	19 35
The Naze of Norway is in	58. 0	21 0
proper Diff. of Latitude 26. Merid. Diff of Latitude 48		
Diff. Long. 1° 25' or 85 Min.		

Merid. Diff. of Latitude	48—	1. 68124
Radius	90.0	10.00000
Diff. of Longitude	85.	1. 92541

Tang. of the Course.	60.33-10. 24817
----------------------	-----------------

Then for the Distance.

Sine Comp. Course — S C	60.33- 9.69166
proper Diff. of Latitude	26 -- 1.41497
is Radius	90.0 - 10.00000

the Distance.	53—	1.72331
---------------	-----	---------

The Course 60° 33', viz. N. E. by E. 4 Deg. 18 Min. westerly, and the Distance 53 Miles.

But here we may see the intolerable Error of the Plain Chart, the Ship being at z, and the Naze of Norway at the Point ©, the Extent between them being applied to the Graduated Line 16. 16, and allowing 60 Miles to each Degree, gives above 170 Miles from the Ship at z to the Port at ©, and the Course between East and East and by North, a most unsufferable error.

I know it is objected by some that notwithstanding what can be said against the Plain Chart, it is still the most useful and frequent amongst us, Witness a great part of the Charts and Waggoners that are now Extant, both in *Dutch* and *English*, and if the Plain Chart was so grossly False in so short a Voyage as from *Lambrough-Head* to the Naze of *Norway*, it would seem that those Plain Charts and Waggoners should not be so much Encouraged, or being used should not answer their End so generally well as they do.

I Answer, I take it for granted that those Charts are not grounded upon that Projection, that the Degrees of Longitude and Latitude are everywhere Equal, as those commonly and properly call Plain Charts are, (for we find no such Thing as Degrees of Longitude upon them) but they are projected upon the same Ground that my Third Chart, before inserted, is grounded upon, viz. The True Course and Distance from Place to Place is found, either the Latitude and Longitude according to Mercator Sailing, as I have directed in the Projection of the Chart, or else the Course and Distance from Place to Place is found by Experience; those that have sailed there observing diligently what Course (with all proper Allowance for Variation, &c.) and what Distance carried them from one Place to another; and thus comparing their Observations of the kind with the Observations of others, and correcting their Observations by their Observed Latitude, &c. And thus one observing in one Place of the World and another in another, and these Observations being compared, and the most agreeable chosen out and collected, may probably have given Rise to our late Waggoners now Extant, which, tho' in Form of Plain Charts, yet in that Case must needs be true, and be depended upon: For altho' the World is Globular and not Plain, yet it is Evident, that what once the Course and Distance between any two Places, shall always be the Course and Distance between them. As for Example, Suppose after all Allowance given for Variation, Lee-way, Currents, &c. I find that a N. E. by E. Course 240 Miles, or 80 League carries me from *Buchanness* to some known Place on the Coast of *Norway*; 'tis certain the same Course and Distance made good shall always do the same; and therefore if that Course and Distance was laid down upon any Chart between these two Places, I might safely depend upon that Chart for my next going there.

Indee

Indeed it may be Objected, Who can tell how to allow so exactly for Variation and Lee-way, but especially for unknown Currents, as to depend upon their Reckoning for the True Course and Distance from Place to Place.

I Answer, I agree to that, but yet when two, three, or more Ships sail upon the same Voyage, and find their Accounts nearly to agree, this may make them somewhat more confident of their Reckoning, and of the Truth of it; and this I take to be a Reason of the Improvements that are yet daily made in Charts and Waggoners; these Charts and Tables of Latitude and Longitude which are of a later Date, having doubtless attained nearer the Truth by a greater Confluence of Observations, and thereby differing more or less from those of more Ancient Date, both in Latitude, but chiefly in Longitude of Places; which Difference we must impute to our attaining nearer to the Truth, and to Mistakes formerly committed, the Places themselves remaining Fixed and Immoveable as to their Situation upon the Surface of the Earth.

From what hath been said it will follow that it is not necessary to dissuade any Mariner from the Use of those Charts and Waggoners now in Print, but it is rather an Encouragement to use them, and trust to them as very good Helps; but let not this be an Inducement to Persons that have had plentiful Experience of the Truth and Sufficiency of those Charts and Waggoners, presently to decline the Use of them and fall to Work to make Charts of their own, and Trust to them, if they have no other Way for it but that Hypothesis of supposing the Degrees of Latitude and Longitude to be every where equal (which I have sufficiently proved is not the Ground of the Projection of those true Sea-Charts now in Use) the absurd and intolerable Falshood of which Hypothesis aforesaid I have sufficiently proved and demonstrated,

Note, Whereas in the Examples before-going, in the three Days Works of keeping a Reckoning, I did for the more Expedition find my Difference of Longitude by the Traverse Table, by the Rule there delivered for that purpose; but yet if your Voyage be long, or near the Pole, where the Degrees of Longitude grow much less, you may, if you distrust the Truth of this Method, Examine your Longitude once in three or four Days, by this Proportion following.

The Ship having sail'd from Latitude 54. 8, to Latitude 57. 34, the proper Difference of Latitude is 206, and the Meridional Difference of Latitude is 368, and Departure made good is 105. 2.

Therefore As proper Diff. of Lat. 206	Co. Ar. 7.68614
To Merid. Diff. of Lat. 368	2.56584
So Departure	105.2 ——— 2.02201
To Diff. of Longitude	188 ——— 2.27399

Diff. of Longitude 188 min. or 3 deg. 8 min. added to the Longitude sail'd from, 16, 26, the Sum 19 34 is the Longitude come to, differing but one minute from what is found by the Traverse Table, altho' that is found at three Operations.

And now, seeing I have in the former Part of this Book laid down Methods for Working the several Cases and Questions in Navigation, and keeping a Reckoning both in Longitude and Latitude, not only by given Numbers, which I have called *Arithmetical Navigation*, but also without any Books, Tables, or Instruments, by a new Method never yet known nor published: I shall Instance in the first Day's Work in both Ways of Operation, it being too tedious to Instance in all the three Days Works, especially seeing there are sufficient Examples given of each Method elsewhere; and first by the given Numbers in *Arithmetical Navigation*.

The Course that Day is N. E. by N. 98 Miles.

The given Number for three Point to find. $\left\{ \begin{array}{l} \text{Diff. Lat. is } 8315 \\ \text{Departure is } 5556 \end{array} \right.$

For Diff. Latitude.

98
83

294
784

for the Departure.

98
555

490
490
490

The Departure
or Easting 54.
39, or rather
54. 4.

81||34 Diff. Lat. 81. 3.

It should be 81. 5, but the Error is only $\frac{2}{10}$, and is occasioned by Omitting the two last Figures of the given Number.

54||390

Diff. Latitude 81 3, or 1 deg. 21 min. hence the Latitude come to is 55 deg. 29 min.

For Difference of Longitude, the Middle Latitude is 54 48, but the next greater whole Degree is 55, whose given Number in the second Table is 5735 but I shall only use the first two Figures 57.

Departure with Cyphers
Given Number, or Divisors

(2
3 x 5
8 4 4 0 95
8 7 7
8

The Diff of
Long. 95 m.
or 1 d. 35 m.
the Remain.
being but a
Fraction of a
Minute, we
reject it.

The

The same Day's Work cast up by the new Method.

The Course 33 45, or $33\frac{1}{4}$, the Distance 98 Miles.
For the Natural Radius for $33\frac{1}{4}$ deg. by Method
the Second, they that can work by cros Multiplicati-
on, need not reduce the Fraction to a Decimal, but
square it as below.

$33\frac{1}{4}$
 $33\frac{1}{4}$

33 by 33 is 1089
 $\frac{1}{4}$ of 33 is $24\frac{1}{4}$
The same again $24\frac{1}{4}$
 $\frac{1}{4}$ of $\frac{1}{4}$ we Reject.

1138 $\frac{1}{2}$
Mult. by 3

3.415 $\frac{1}{2}$
57.3

Nat. Rad. 60.7

As 60.7 to 98:: so $33\frac{1}{4}$ to Depar.

$33\frac{1}{4}$

294
2943
7 60.7) 3307.0 (544
2720
2920
492

For Diff. Lat. by Rule the Third,
Sum of the Sides 1534
Dif. of the Sides 436

9144
4572
6096

Product. 6644.64 (81.5 Squ.
64 (root of the
Product &
161) 244 Diff. Lat.
161 required.

1831

For

For Diff. Longitude, the Complement of middle Latitude is 35, its Natural Radius is 61: Therefore as 35 to 54. 4. so 61 to Diff. of Longitude.

$$\begin{array}{r}
 54.4 \\
 61 \\
 \hline
 54.4 \\
 3164 \\
 \hline
 3318.4
 \end{array}
 \qquad
 \begin{array}{r}
 35 \overline{) 3318} \quad 94\frac{2}{3} \\
 \underline{168} \\
 28
 \end{array}
 \qquad
 \begin{array}{l}
 \text{or rather } 95 \text{ min. or } 1 \\
 \text{deg. } 35 \text{ min. the Diff. of} \\
 \text{Longitude required.}
 \end{array}$$

And thus you see the Excellency and Usefulness of this New Method, by which altho' by stress of Weather, or Cruelty of Enemies, you had lost all Charts, Books, Tables, and Instruments, yet you may without any of them keep as Just an Account of your Ship's Way, both in Longitude and Latitude, as you can with them; as this and other Examples inserted elsewhere in this Book make manifest.



C H A P. VIII.

S E C T. I.

How to make an Orthographick Projection of the Sphere, commonly called the Analemma; whereby most of the Necessary Questions in Astronomy may be Resolved without Trigonometrical Calculation, only by the Help of Scale and Compasses.

ALTHO' I have not designed this Book for a Treatise of Astronomy, and other Spherical Operations (that being sufficient to make a Treatise of it self) and therefore have supplied that by Inserting all the Astronomical Tables, ready Calculated, that are of Use in the Practice of Navigation: And have also laid down a Method for finding the Variation of the Compass, without Azimuth or Amplitude, &c. yet for the sake of such as delight in Astronomical Operations, I shall shew the Learner how to solve all Necessary Astronomical Questions by the Analemma, or Orthographick Projection, upon the Plain of the Meridian; And in this Manner of Projection, the Eye is supposed to be Perpendicular to that great Circle upon whose Plain the Projection is made, and at an infinite Distance from the said Circle; so that any Line let fall from the Eye upon any Place within the said Circle, shall be Perpendicular to the said Plain, and then will the Primitive Circle

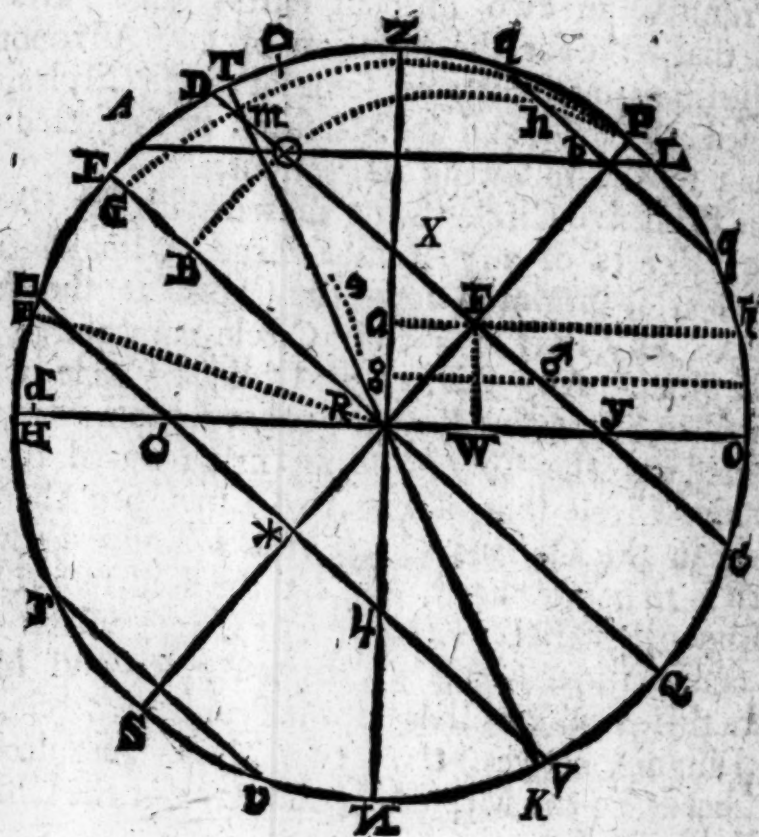
Circle (or Meridian of the Place, when the Projection is upon the Plain of the Meridian) be a perfect Circle. All right Circles that divide the Projection in 2 equal Parts are straight Lines, or Diameters, of the Primitive Circle, and all Oblique Circles that Divide the Primitive into two unequal Parts, and yet Touch it at Opposite Points are Semi-Ellipses, or half Oval Circles; and all Parallels, or lesser Circles, are right Lines, cutting the Primitive in two unequal Parts; and Parts of Lines that serve for the Solution of any Astronomical Questions, are Parts of some of those Circles, or supposed to be so, and are Measured or Projected according to the following Directions.

The Primitive Circle (being drawn with the Chord of 60 Degrees of any Radius large or small) any Part of it is measured upon the Chords to the same Radius. Any Part of a right Circle is measured upon the Sines. Any Part of an Oblique Circle (when required to be measured, which is but seldom) may be measured on the Chords, being first reduced to the Primitive Circle thus, Draw two Lines thro' the two Points in the Oblique Circle, the Distance between which is to be measured, and let the said two Lines be Drawn Parallel to that Right Circle which cuts the said Oblique Circle at Right Angles, and Mark where these two Parallels cut the Primitive Circle, and the Distance between these two Marks measured on the Chords, is the Measure of the Arch of the Oblique Circle required.

Note, There is no Way to Project these Oblique Circles, but by finding a great Number of Points through which they are to pass, and so by a steady Hand, or the help of a Bow, draw it thro' the said Points; but the Operation being Tedious, and of little Use, it is seldom put in Practice: Nevertheless I shall hereafter shew how they are done, as also all the rest, as in the following Example.

*An Orthographick Projection of the Sphere upon
the Plain of the Meridian, For*

		d.	m.
Sun's	Latitude of London	51	32
	Declination North	22	30
	Altitude	45	00



First, With the Chord of 60, Draw the Circle *PE*
S Q, to represent the Meridian; then draw the Dia-
meter *HO* to represent the Horizon, and at Right
Angles to it Draw the Line *Z N* to represent the
Prime Vertical; then set off the Latitude 51 32 (taken
off the Chords) from *o* to *P*, and from *H* to *S*, and
Draw the Line *P R S* to represent the Axis of the
World, *P* the North Pole, and *S* the South Pole:
Then at Right Angles with the Line *PS*, Draw the
Line

Line $E Q$ to represent the Equator: Then set the Chord of the given Declination $22. 30$ from E to D , and from Q to C , and Draw the Line $D C$ the Parallel of the Sun's Declination: Set off also the Chord of the given Altitude $45. 0$, from H to A , and from O to L , and draw the Line $A L$ the Parallel of the Sun's Altitude: Then where these two Parallels $A L$, and $D C$ intersect each other, as at the Point $\odot$, is the Place of the Sun at that time. Set off the Chord of $23. 30$, the Sun's greatest Declination from E to T , and from Q to K , and Draw the Line $T K$ to represent the Ecliptick: Set off also the Chord of $23. 30$ from P to q and g , and Draw the Line $q g$ to represent the Arctick Circle, and the same from s to r and v , and Draw the Line $r v$ to represent the Antarctick Circle: Then from P , thro' the Point $\odot$ draw the Meridian $P b \odot B$; thus here is given in this Meridian the Point P and the Point $\odot$, then to find the Point B , another Point thro' which this Meridian is to pass, Divide the Line $E R$ after the same Proportion that the Line $D F$ is Divided, at the Point $\odot$, that is, as $F D$ to $F \odot$, so $R E$ to $R B$, and make the Mark B , and by the same Means find the Point b in the Line $q b$: Then thro' the Points $P b \odot B$ with a Bow, Curving or Bending gradually, draw the Prick'd Curving Line $P b \odot B$ to represent a Part of another Meridian: Then thro' the Point M (where the Ecliptick crosseth the Parallel of the Sun's Declination) draw the Arch $P m G$ by the aforesaid Method; all which being finished you may proceed to answer the following Problems.

1. To find the Sun's Longitude or Distance from the next Equinoctial Point.

The Sun's Longitude, or Distance from the next Equinoctial Point, is an Arch of the Ecliptick, contain'd between the Center R (or Intersection of the Ecliptick and Equator) and the Point m , (the Intersection of the Ecliptick and Parallel of Declination)

so

so here Rm measured on the Sines, is the Sun's Distance from the next Equinoctial Point.

2. *Of the Sun's right Ascension.*

It is an Arch of the Equator, contained between the Equinoctial Point R , and the Point where the Meridian drawn thro' m cuts the Equator, as in G , so RG , measured on the Sines, gives the right Ascension required.

Note, If it be thought too much Trouble to draw these Meridians, all these Problems which can be done by the Help of these Meridians, may be done without them, if you reduce the lesser Circles to the common Radius; therefore Fm is the Sine of the Sun's right Ascension to a lesser Radius $F D$; which may be reduced to the common Radius thus. Suppose I would find the Sun's right Ascension: Set $F D$ from R to d , upon the Line $R H$, then with the Extent $F m$, and one foot in d , describe the Arch e ; a Ruler laid from R , by the Extremity of that Arch will cut the Primitive Circle in o ; then Ho measured on the Chords is equal to $F m$, the Sun's right Ascension required.

Note, When any Arch of a lesser Circle is to be measured, it must be first reduced to the common Radius, and measured as before.

3. *To find the Hour of the Day.*

The Hour from six a Clock is an Arch of the Parallel of Declination, contain'd between the Line PS and the Point Sun, which reduced to the common Radius, and Measured as in *Problem* the second, gives the Degrees of a great Circle, which allowing 15 degrees for an hour, and one degree to 4 Minutes of Time, gives the Hour from 6.

4. *To find the time of the Sun's Rising and Setting.*

The Arch Fy reduced to the common Radius by *Prob.* 2. and the Degrees reduced to Time by *Prob.* 3. gives the Hour that the Sun Rises before 6, or Sets after 6.

Note,

Sect. 1. *Projection of the Sphere.* 257

Note, If the Sun had had $22^{\circ} 30'$ South Declination, it must have been represented by the Parallel $\square$, and then the Arch $\delta *$ reduced as before would have given the Time of Rising after, or the Sun's Setting before 6 a Clock.

5. *To find the Length of the Day or Night.*

That part of the parallel of Declination which is above the Horizon, reduced as in *Prob. 2* and *3*, gives the Length of the day, and that Part which is below the Horizon gives the Length of the Night: Thus $D y$ gives the Length of the Day, and $y c$ the Length of the Night, when the Sun hath $22^{\circ} 30'$ North Declination, and $\square \delta$ gives the Length of the Day, and $\delta \Delta$ the Length of the Night in the same South Declination.

6. *To find the Sun's Amplitude.*

The Sun's Amplitude is an Arch of the Horizon contained between the East or West Point, and the Point where the Sun rises or sets: Thus $R y$ is the Amplitude in North, or $R \delta$ in South Declination, which because it is an Arch of a great Circle is measured on the Sines.

Note, The Amplitude is always of the same Denomination with the Declination, whether North or South.

7. *To find what Hour the Sun will be due East or West.*

The Sun is East or West when in the Line $Z N$, and it is 6 a Clock when the Sun is in the Line $P S$, therefore the Arch $X F$, reduced by *Prob. 2* and *3*, gives the Hour after 6 in the Morning, that the Sun is due East, or 6 in the Evening that it is due West.

8. *To find the Sun's Altitude when East or West.*

The Arch $R x$ measured on the Sines, gives the Sun's Altitude when East or West.

9. *To find the Sun's Altitude at 6 a Clock.*

The Arch $F w$ equal to $R a$, measured on the Sines, gives the Sun's Altitude at 6.

10. To find the Sun's Azimuth at 6.

The Arch $a P$, reduced by Prob. 2. gives the Azimuth at 6 required, accounting the Azimuth from the East or West; but if from the North the Arch $P h$ reduced as before answers the Problem.

11. To find the Sun's Azimuth at any given Hour, As suppose 5 in the Morning, or 7 at Night.

I have thought fit to insert this Problem, not only for its Usefulness, but because it is performed by another Method of reducing a lesser Circle to the common Radius, which is the Inverse of that Way of reducing mentioned in Prob. 2. As for Example, Because 5 in the Morning is one Hour before 6, and every Hour of Time is equal to 15 Degrees of a greater (or lesser) Circle; therefore set off 15 Degrees from F towards y , which is done thus.

Set off FC from R to d upon the Line $R H$: Set off 15 of the Chords from H to $\square$, and draw the prick'd Line $R \square$; the nearest Distance from the Point d to that Line set from F to σ is 15 Degrees, or an Hour of Time in that lesser Circle, and the Point σ is the Place of the Sun at 5 in the Morning, and the Arch $\rho \sigma$ reduced to the common Radius by Prob. 2. gives the Sun's Azimuth from the East Northwards at 5 in the Morning, or from the West Northwards at 7 in the Evening; and by this Method you may set off any Number of Degrees upon any Parallel or lesser Circle, a Thing of great use in Orthographick Projection.

the Circle is to pass the Center is found by the first Proposition of this Book. **SECT. II.** Of the Stereographic Projection of the Sphere, upon the Plain of the Meridian.

IN this Kind of Projection there are four Sorts of Circles, viz. The primitive Circle, a right Circle, an oblique Circle, and a parallel Circle.

1. The Primitive is a perfect round Circle, upon whose Plain the Projection is made; and in this Case it is the Meridian of the Place; as here the Circle ZNO is the primitive Circle.

2. A right Circle is a straight Line, or Diameter of the primitive Circle, which cuts the primitive in two opposite Points, and divides it into two equal parts, as HAE the Horizon, or BAQ the Equator, &c.

3. An oblique Circle cuts the Primitive at two opposite Points, but divides it not into two equal Parts, as ZON , an Aximuth, or POS a Meridian.

4. A parallel Circle is a lesser Circle, neither cutting the primitive in opposite Points, nor dividing it in two equal Parts, as DOF , a parallel of Declination, or BOC , a parallel of Altitude.

PROB. I. How to find the Center of any Circle.

1. The primitive Circle is always drawn with the Chord of 60 Degrees, upon the Center A .

2. A right Circle, (being a straight Line) hath no Center.

3. The Center of an oblique Circle always falls in that right Circle which cuts the said oblique Circle in two equal Parts; thus the Center of the Circle ZON falls in the right Circle HAO , and the Center of the Circle POS falls in the right Circle EAQ ; and if you have three Points, as ZON , thro' which

the Circle is to pass, the Center is found by the first Geometrical Problem at the Beginning of this Book but if you have given the Angle that the oblique Circle is to make with the primitive Circle, set the Tangent of the said Angle from A upon the Line HAO , or with the Secant of the said Angle, and one Foot in Z or N , with the other cross the Line HAO , either Way you shall find the Center of the oblique Circle required.

4. For the Center of a parallel Circle, having its Distance from the right Circle to which it is Parallel given, set off the Chord of that Distance upon the primitive Circle from each End of the right Circle and the half Tangent of the said Distance from the center A , upon that right Circle which cuts the other at right Angles, and so you have three Points through which the Parallel is to pass to find its Center by the sixth Geometrical Problem.

Or thus, Suppose I would find the Center of the Parallel of Declination $D \odot F$, set the Tangent of the Complement of the Sun's Declination from D or F , or the Secant of the same from A upon the line SA continued, and that shall find the Center required.

PROB. II. To find the Pole of any Circle.

Note, The Pole of any great Circle is always 90 deg. from its Periphery: Therefore,

1. The Pole of the Primitive is always at its Center A .

2. The Pole of a right Circle is always in the Primitive, as the Pole of the right Circle HAO is at Z , and the Pole of the right Circle EAL is at P and S , &c.

3. For the Pole of an oblique Circle, as suppose the Circle $Z \odot N$, observe where the said oblique Circle cuts the right Circle, which it cuts at right Angles, as here in the Point G , lay a Ruler from Z

It cuts the Primitive in I , set off 90 of the Chords from I to K , a Ruler laid from Z to K cuts the Circle in U in L , the Pole of the oblique Circle required.

4. The Pole of a parallel Circle is always in the half of that Right Circle to which it is parallel, thus the Pole of the Parallel $D \odot F$ is at P , the Pole of the right Circle $E \odot A \odot Q$.

Note, An Arch of a parallel Circle is never made a Side of a spherical Triangle, they being all composed of arches of great Circles, whether Primitive, Right, or Oblique.

PROB. III. How to measure any Side of a Triangle, or Arch of a great Circle.

1. Any Arch of the Primitive is always measured upon the Chords.

2. Any Arch of a right Circle is always measured upon the half Tangents.

3. Any Arch of an oblique Circle is measured thus, Lay a Ruler from the Pole of the said oblique Circle, over the Extremities of the said Arch, and observe where it cuts the Primitive, and that Distance measured on the Chords gives the Quantity of the Arch required.

Example, Suppose I would measure the Arch $\odot \omega$ of the Circle $P \odot S$: Lay a Ruler from L (the Pole of the said Circle) to $\odot$, it cuts the Primitive in B : again, a Ruler laid from L to ω cuts the Primitive in X , the Distance $B X$, measured on the Chords gives the Quantity of the Arch $\odot \omega$ required.

PROB. IV. How to measure any spherical Angle.

This one Rule is Universally useful in all Cases whether the Sides including the Angle be Arches of the Primitive, Right, or Oblique Circles) viz. Lay a Ruler from the Angle over the Poles of the two Circles

including the Angle, and observe at what Place the Ruler cuts the Primitive; for that Distance measured on the Chords gives the Quantity of Angle required.

Example. I would measure the Angle $Z \odot P$ of the Triangle $Z \odot P \odot L$: Lay a Ruler from $\odot$ to L (the Pole of one of the Circles including the Angle) it cuts the Primitive in E ; and then a Ruler laid from $\odot$ to M (the Pole of the other Circle including the Angle) it cuts the Primitive in A ; the Arch $E \odot A$ measured on the Chords gives the Quantity of the Angle $Z \odot P$ required.

By these Directions, and the Inverse of them, you may set off any Number of Degrees, or lay down any Angle required, as will be further illustrated in the following Example; the Room assigned for this Appendix not permitting me to enlarge upon it.

Example. Suppose I would measure the Arch $\odot$ in the Circle $P \odot S$: Lay a Ruler from L (the Pole of the said Circle) to $\odot$; it cuts the Primitive in A ; then a Ruler laid from L to S cuts the Primitive in X ; the Distance $A \odot X$ measured on the Chords gives the Quantity of the Arch $\odot$ required.

Example. Suppose I would measure the Arch $\odot$ in the Circle $P \odot S$: Lay a Ruler from L (the Pole of the said Circle) to $\odot$; it cuts the Primitive in A ; then a Ruler laid from L to S cuts the Primitive in X ; the Distance $A \odot X$ measured on the Chords gives the Quantity of the Arch $\odot$ required.

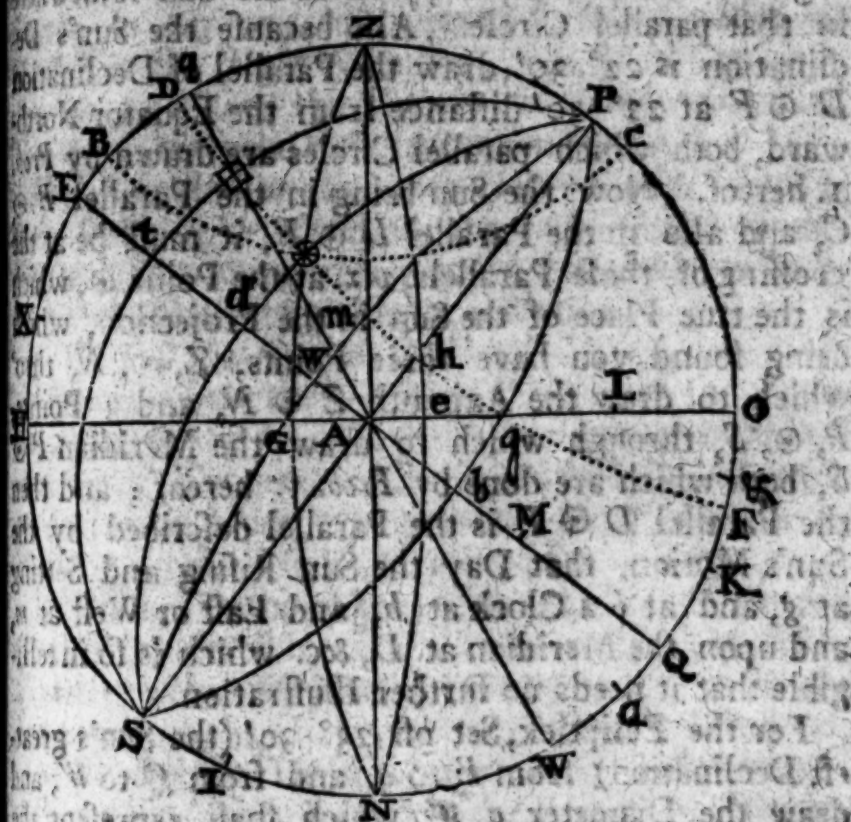
PROB. IV. How to measure any Spherical Angle.

This one Rule is Universally useful in all Cases, whether the sides including the Angle be Arches of Primitive, Right, or Oblique Circles; viz. Lay a Ruler from the Angle over the Poles of the two Circles

*A Stereographick Projection of the Sphere, upon
the Plain of the Meridian. For,*

Latitude of London
Sun's { **Declination**
 { **Altitude**

51—32
22—30
45—00



*How to Project the Sphere Stereographically upon the
Plain of the Meridian.*

First with the Chord of 60 Degrees, and one Foot
of the Compasses in the Center *A*, describe the Pri-
mitive Circle *Z H N O* to represent the Meridian;
Draw the Diameter *H A O* to represent the Horizon,
and at right Angles to it draw the Diameter *Z A N*

the Azimuth of East and West: Then because the Pole is $51^{\circ} 32'$ above the Horizon, set off $51^{\circ} 32'$ of the Chords from O to P , and from H to S , then is P the North Pole, and S the South Pole: Draw the Diameter $S P$, the Axis of the World, and Hour Line of 6, and at right Angles to it, the Diameter $E G$ the Equator: Then because the Sun's Altitude above the Horizon is 45 deg. draw the Parallel $B \odot C$ 45 deg. above the Horizon; then is the Sun somewhere in that parallel Circle. Also because the Sun's Declination is $22^{\circ} 30'$, draw the Parallel of Declination $D \odot F$ at $22^{\circ} 30'$ distance from the Equator Northward, both which parallel Circles are drawn by *Prob. 1.* hereof. Now the Sun being in the Parallel $B \odot C$, and also in the Parallel $D \odot F$, it must be at the crossing of those Parallels, viz. at the Point $\odot$, which is the true Place of the Sun in the Projection, which being found you have three Points, $Z, \odot, N$, thro' which to draw the Azimuth $Z \odot N$, and 3 Points $P, \odot, S$, through which to draw the Meridian $P \odot S$, both which are done by *Prob. 1.* hereof; and then the Parallel $D \odot F$ is the Parallel described by the Sun's Motion, that Day the Sun Rising and Setting at g , and at 6 a Clock at b , and East or West at m and upon the Meridian at D , &c. which is so intelligible that it needs no further Illustration.

For the Ecliptick, Set off $23^{\circ} 30'$ (the Sun's greatest Declination) from E to q , and from Q to W , and draw the Diameter $q W$, which shall represent the Ecliptick.

By *Prob. 1.* hereof, Draw the Meridian $P m S$ and the Azimuth $z b n$, and thro' the Point $\square$ (where the Ecliptick cuts the Parallel of Declination) draw the Meridian $P \square S$.

1. To find the Sun's Longitude or Distance from the nearest Equinoctial Point.

The Arch of the Ecliptick $A \square$, measured on the half Tangents, and the Degrees and Minutes found reduced

reduced to Signs, Degrees, and Minutes of the Ecliptick, allowing 30 Degrees to a Sign, &c. gives the Sun's Longitude required.

2. To find the Sun's right Ascension.

The Arch of the Ecliptick A measured on the half *Equator* Tangents, gives the Sun's right Ascension when he is in *Aries*, *Taurus*, or *Gemini*; but if in *Cancer*, *Leo*, or *Virgo*, the Degrees so found subtracted from 180, gives the right Ascension: And when the Sun is in *Libra*, *Scorpio*, or *Sagittary*, the Degrees so found added to 180, gives the right Ascension; but if in *Capricorn*, *Aquarius*, or *Pisces*, the Degrees so found subtracted from 360, shews the right Ascension required.

Note, For finding the exact Degrees and Minutes of the Sun's right Ascension, the same Rules of adding and subtracting the Degrees found are to be used in the Orthographick Projection also.

3. To find the Hour of the Day.

Observe where the Meridian $P \odot S$ cuts the Equator, as in d , the Arch $A d$ of the Equator measured on the half Tangents, and reduced to Time, allowing 15 deg. to an Hour, &c. gives the Hour past 6 in the Morning, or the Hours wanting of 6 at Night.

Or thus. In the oblique Triangle $Z P \odot$, the Angle at P , measured by *Prob. 4.* and reduced to Time as above, gives the Hours wanting of 12, if in the Forenoon, or the Hours past 12, if in the Afternoon.

4. To find the Time of the Sun's Rising and Setting.

Thro' the Point g (where the Parallel of Declination cuts the Horizon) draw the Meridian $P g S$, and observe where it cuts the Equator, as at B , the Arch $A b$ measured on the half Tangents, and the Degrees reduced to Time, give the Hours and Minutes that the Sun rises before 6 in the Morning, or Sets after 6 in the Evening; or if in South Declination, where the Parallel of Declination intersects the Horizon on the other Side of the Line $P S$, or Hour Line of 6, it gives Sun's Rising after 6, or Setting before 6, &c.

5. To

5. *To find the Length of the Day or Night.*

The Hour and Minute of Sun's Setting doubled gives the Length of the Day, the Time of Sun's Rising doubled gives the Length of the Night.

6. *To find the Sun's Amplitude.*

The Arch of the Horizon $A g$ (being an Arch contained between the Sun's Rising or Setting at g and the due East or West Point at A) measured on the half Tangents gives the true Amplitude from the East or West required.

7. *To find what Hour the Sun will be East or West.*

The Sun is East or West in m , the Point where the Parallel of Declination cuts the prime Vertical, or East and West Line $Z A N$, therefore having drawn the Meridian $P m S$, observe where it cuts the Equator, as at w , then $A w$ measured on the half Tangents, and reduced to Time, gives the Hour after 6 in the Morning that the Sun is due East, or the Hour before 6 in the Evening that the Sun is due West.

8. *To find the Sun's Altitude when East or West.*

The Arch $A m$, measured on the half Tangents, answers the Question, and gives the Sun's Altitude when East or West.

9. *To find the Sun's Altitude at 6 a Clock.*

The Sun is in the Point b at 6 a Clock, therefore the Arch $b e$ measured by Prob. 3. gives the Sun's Altitude at 6 required.

10. *To find the Sun's Azimuth at 6 a Clock.*

The Arch of the Horizon $A e$, measured on the half Tangents, gives the Sun's Azimuth from the East or West required, whose Complement to 90 is the Azimuth from the North, &c.

11. *To find the Sun's Azimuth at any Hour or Altitude, as suppose when in the Point $\odot$ in this Projection.*

From Z to N , and thro' the Point $\odot$, draw the Azimuth $Z \odot N$, as before directed, and observe where it cuts the Horizon as in G , then the Arch

AG measured on the half Tangents, gives the Azimuth from the East or West required.

Thus have I given you a Taste of all the most useful Problems, relating to the Orthographick and Stereographick Projections of the Sphere; of which I shall add no more at this Time; intending, if God permit, to write a Treatise of the various Methods for Projecting and Solving of Spherical Triangles, with the Application thereof to Astronomy, Dyalling, &c. in the mean Time the Reader is here supplied with Methods for solving all the most necessary Questions relating to his daily Practice in Navigation.

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A Large and very Useful

TABLE

OF

DIFFERENCE

OF

Latitude & Departure,

IN

Minutes and Tenth Parts,
to every Degree and Quarter-Point

OF THE

COMPASS,

FOR THE

Exact Working

OF A

TRAVERS.

Diff	1 Deg.		2 Deg.		3 Point		3 Deg.		4 Deg.		5 Deg.	
	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep
1	01.0	00.0	01.0	00.0	01.0	00.0	01.0	00.0	01.0	00.1	01.0	00.1
2	01.0	00.0	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.2
3	03.0	00.1	03.0	00.1	03.0	00.1	03.0	00.1	03.0	00.2	03.0	00.3
4	04.0	00.1	04.0	00.1	04.0	00.1	04.0	00.2	04.0	00.2	04.0	00.3
5	05.0	00.1	05.0	00.2	05.0	00.2	05.0	00.2	05.0	00.3	05.0	00.4
6	06.0	00.1	06.0	00.2	06.0	00.3	06.0	00.3	06.0	00.4	06.0	00.5
7	07.0	00.1	07.0	00.2	07.0	00.3	07.0	00.4	07.0	00.5	07.0	00.6
8	08.0	00.1	08.0	00.3	08.0	00.4	08.0	00.4	08.0	00.6	08.0	00.7
9	09.0	00.2	09.0	00.3	09.0	00.4	09.0	00.5	09.0	00.6	09.0	00.8
10	10.0	00.2	10.0	00.4	10.0	00.5	10.0	00.5	10.0	00.7	10.0	00.9
11	11.0	00.2	11.0	00.4	11.0	00.5	11.0	00.6	11.0	00.8	11.0	01.0
12	12.0	00.2	12.0	00.4	12.0	00.6	12.0	00.6	12.0	00.8	12.0	01.0
13	13.0	00.2	13.0	00.5	13.0	00.6	13.0	00.7	13.0	00.9	12.9	01.1
14	14.0	00.2	14.0	00.5	14.0	00.7	14.0	00.7	14.0	01.0	13.9	01.1
15	15.0	00.3	15.0	00.5	15.0	00.7	15.0	00.8	15.0	01.0	14.9	01.2
16	16.0	00.3	16.0	00.6	16.0	00.8	16.0	00.8	16.0	01.1	15.9	01.4
17	17.0	00.3	17.0	00.6	17.0	00.8	17.0	00.9	17.0	01.2	16.9	01.4
18	18.0	00.3	18.0	00.6	18.0	00.9	18.0	00.9	17.9	01.3	17.9	01.6
19	19.0	00.3	19.0	00.7	19.0	00.9	19.0	01.0	18.9	01.3	18.9	01.7
20	20.0	00.4	20.0	00.7	20.0	01.0	20.0	01.0	19.9	01.4	19.9	01.7
21	21.0	00.4	21.0	00.7	21.0	01.0	21.0	01.1	20.9	01.5	20.9	01.8
22	22.0	00.4	22.0	00.8	22.0	01.1	22.0	01.1	21.9	01.5	21.9	01.9
23	23.0	00.4	23.0	00.8	23.0	01.1	23.0	01.2	22.9	01.6	22.9	02.0
24	24.0	00.4	24.0	00.8	24.0	01.2	24.0	01.3	23.9	01.7	23.9	02.1
25	25.0	00.4	25.0	00.9	25.0	01.2	25.0	01.3	24.9	01.7	24.9	02.1
26	26.0	00.5	26.0	00.9	26.0	01.3	26.0	01.4	25.9	01.8	25.9	02.2
27	27.0	00.5	27.0	00.9	27.0	01.3	27.0	01.4	26.9	01.9	26.9	02.4
28	28.0	00.5	28.0	01.0	28.0	01.4	28.0	01.5	27.9	02.0	27.9	02.4
29	29.0	00.5	29.0	01.0	29.0	01.4	29.0	01.5	28.9	02.0	28.9	02.5
30	30.0	00.5	30.0	01.1	30.0	01.5	30.0	01.6	29.9	02.1	29.9	02.6
31	31.0	00.5	31.0	01.1	30.9	01.5	31.0	01.6	30.9	02.2	30.9	02.7
32	32.0	00.6	32.0	01.1	31.9	01.6	31.9	01.7	31.9	02.2	31.9	02.8
33	33.0	00.6	33.0	01.2	32.9	01.6	32.9	01.7	32.9	02.3	32.9	02.9
34	34.0	00.6	34.0	01.2	33.9	01.7	33.9	01.8	33.9	02.4	33.9	03.0
35	35.0	00.6	35.0	01.2	34.9	01.7	34.9	01.8	34.9	02.4	34.9	03.1
36	36.0	00.6	36.0	01.3	35.9	01.8	35.9	01.9	35.9	02.5	35.9	03.1
37	37.0	00.7	37.0	01.3	36.9	01.8	36.9	01.9	36.9	02.6	36.9	03.2
38	38.0	00.7	38.0	01.3	37.9	01.9	37.9	02.0	37.9	02.7	37.9	03.3
39	39.0	00.7	39.0	01.4	38.9	01.9	38.9	02.0	38.9	02.7	38.9	03.4
40	40.0	00.7	40.0	01.4	39.9	02.0	39.9	02.1	39.9	02.8	39.8	03.5
41	41.0	00.7	41.0	01.4	40.9	02.0	40.9	02.1	40.9	02.9	40.8	03.6
42	42.0	00.7	42.0	01.5	41.9	02.1	41.9	02.2	41.9	02.9	41.8	03.7
43	43.0	00.8	43.0	01.5	42.9	02.1	42.9	02.2	42.9	03.0	42.8	03.8
44	44.0	00.8	44.0	01.5	43.9	02.2	43.9	02.3	43.9	03.1	43.8	03.8
45	45.0	00.8	45.0	01.6	44.9	02.2	44.9	02.4	44.9	03.1	44.8	03.9
46	46.0	00.8	46.0	01.6	45.9	02.2	45.9	02.4	45.9	03.2	45.8	04.0
47	47.0	00.8	47.0	01.6	46.9	02.3	46.9	02.5	46.9	03.3	46.8	04.1
48	48.0	00.8	48.0	01.7	47.9	02.3	47.9	02.5	47.9	03.4	47.8	04.2
49	49.0	00.9	49.0	01.7	48.9	02.4	48.9	02.6	48.9	03.4	48.8	04.3
50	50.0	00.9	50.0	01.8	49.9	02.4	49.9	02.6	49.9	03.5	49.8	04.4
Diff	D. p. Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	D. p. Lat.	Diff.
	89 Deg.		88 Deg.		77 Point		87 Deg.		86 Deg.		85 Deg.	

of Latitude and Departure.

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1 Deg.	2 Deg.	3 Point	4 Deg.	5 Deg.	Diff.
Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
51.0 00.2	51.0 01.8	50.9 01.5	50.9 02.7	50.9 03.6	50.8 04.4
52.0 00.9	52.0 01.8	51.9 02.5	51.9 02.7	51.9 03.6	51.8 04.5
53.0 00.9	53.0 01.8	52.9 02.6	52.9 02.8	52.9 03.7	52.8 04.6
54.0 00.9	54.0 01.9	53.9 02.6	53.9 02.8	53.9 03.8	53.8 04.7
55.0 01.0	55.0 01.9	54.9 02.7	54.9 02.9	54.9 03.8	54.8 04.8
56.0 01.0	56.0 02.0	55.9 02.7	55.9 02.9	55.9 03.9	55.8 04.9
57.0 01.0	57.0 02.0	56.9 02.8	56.9 03.0	57.0 04.0	56.8 05.0
58.0 01.0	58.0 02.0	57.9 02.8	57.9 03.0	57.8 04.1	57.8 05.1
59.0 01.0	59.0 02.1	58.9 02.9	58.9 03.1	58.8 04.1	58.8 05.2
60.0 01.0	60.0 02.1	59.9 02.9	59.9 03.1	59.8 04.2	59.8 05.2
61.0 01.1	61.0 02.1	60.9 03.0	60.9 03.2	60.8 04.3	60.8 05.3
62.0 01.1	62.0 02.2	61.9 03.0	61.9 03.3	61.8 04.3	61.8 05.4
63.0 01.1	63.0 02.2	62.9 03.1	62.9 03.3	62.8 04.4	62.8 05.5
64.0 01.1	64.0 02.2	63.9 03.1	63.9 03.4	63.8 04.5	63.8 05.6
65.0 01.1	65.0 02.3	64.9 03.2	64.9 03.4	64.8 04.5	64.7 05.7
66.0 01.1	66.0 02.3	65.9 03.2	65.9 03.5	65.8 04.6	65.7 05.8
67.0 01.2	67.0 02.3	66.9 03.3	66.9 03.5	66.8 04.7	66.7 05.9
68.0 01.2	67.9 02.4	67.9 03.3	67.8 03.6	67.8 04.8	67.7 05.9
69.0 01.2	68.9 02.4	68.9 03.4	68.9 03.6	68.8 04.8	68.7 06.0
70.0 01.2	69.9 02.4	69.9 03.4	69.9 03.7	69.8 04.9	69.7 06.1
71.0 01.2	70.9 02.5	70.9 03.5	70.9 03.7	70.8 05.0	70.7 06.2
72.0 01.2	71.9 02.5	71.9 03.5	71.9 03.8	71.8 05.0	71.7 06.3
73.0 01.3	72.9 02.5	72.9 03.6	72.9 03.8	72.8 05.1	72.7 06.4
74.0 01.3	73.9 02.6	73.9 03.6	73.9 03.9	73.8 05.2	73.7 06.5
75.0 01.3	74.9 02.6	74.9 03.7	74.9 03.9	74.8 05.2	74.7 06.6
76.0 01.3	75.9 02.7	75.9 03.7	75.9 04.0	75.8 05.3	75.7 06.6
77.0 01.3	76.9 02.7	76.9 03.8	76.9 04.0	76.8 05.4	76.7 06.7
78.0 01.4	77.9 02.7	77.9 03.8	77.9 04.1	77.8 05.5	77.7 06.8
79.0 01.4	78.9 02.8	78.9 03.9	78.9 04.1	78.8 05.5	78.7 06.9
80.0 01.4	79.9 02.8	79.9 03.9	79.9 04.2	79.8 05.6	79.7 07.0
81.0 01.4	80.9 02.8	80.9 04.0	80.9 04.2	80.8 05.7	80.7 07.1
82.0 01.4	81.9 02.9	81.9 04.0	81.9 04.3	81.8 05.7	81.7 07.2
83.0 01.4	82.9 02.9	82.9 04.1	82.9 04.4	82.8 05.8	82.7 07.3
84.0 01.5	83.9 02.9	83.9 04.1	83.9 04.4	83.8 05.9	83.7 07.3
85.0 01.5	84.9 03.0	84.9 04.2	84.9 04.5	84.8 05.9	84.7 07.4
86.0 01.5	85.9 03.0	85.9 04.2	85.9 04.5	85.8 06.0	85.7 07.5
87.0 01.5	86.9 03.0	86.9 04.3	86.9 04.6	86.8 06.1	86.7 07.6
88.0 01.5	87.9 03.1	87.9 04.3	87.9 04.6	87.8 06.2	87.7 07.7
89.0 01.5	88.9 03.1	88.9 04.4	88.9 04.7	88.8 06.2	88.7 07.8
90.0 01.6	89.9 03.1	89.9 04.4	89.9 04.7	89.8 06.3	89.7 07.9
91.0 01.6	90.9 03.2	90.9 04.5	90.9 04.8	90.8 06.4	90.7 08.0
92.0 01.6	91.9 03.2	91.9 04.5	91.9 04.8	91.8 06.4	91.6 08.0
93.0 01.6	92.9 03.2	92.9 04.6	92.9 04.9	92.8 06.5	92.6 08.1
94.0 01.6	93.9 03.3	93.9 04.6	93.9 04.9	93.8 06.6	93.6 08.2
95.0 01.6	94.9 03.3	94.9 04.7	94.9 05.0	94.8 06.6	94.6 08.3
96.0 01.7	95.9 03.4	95.9 04.7	95.9 05.0	95.8 06.7	95.6 08.4
97.0 01.7	96.9 03.4	96.9 04.8	96.9 05.1	96.8 06.8	96.6 08.5
98.0 01.7	97.9 03.4	97.9 04.8	97.9 05.1	97.8 06.9	97.6 08.6
99.0 01.7	98.9 03.5	98.9 04.9	98.9 05.2	98.8 06.9	98.6 08.7
100.0 01.7	99.9 03.5	99.9 04.9	99.9 05.2	99.8 07.0	99.6 08.7
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.
89 Deg.	88 Deg.	7 1/2 Point	87 Deg.	86 Deg.	85 Deg.

Diff.	Point		60 Deg.		70 Deg.		80 Deg.		Point		90 Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1
2	02.0	00.2	02.0	00.2	02.0	00.2	02.0	00.2	02.0	00.2	02.0	00.2
3	03.0	00.3	03.0	00.3	03.0	00.3	03.0	00.3	03.0	00.3	03.0	00.3
4	04.0	00.4	04.0	00.4	04.0	00.4	04.0	00.4	04.0	00.4	04.0	00.4
5	05.0	00.5	05.0	00.5	05.0	00.5	05.0	00.5	05.0	00.5	05.0	00.5
6	06.0	00.6	06.0	00.6	06.0	00.6	06.0	00.6	06.0	00.6	06.0	00.6
7	07.0	00.7	07.0	00.7	07.0	00.7	07.0	00.7	07.0	00.7	07.0	00.7
8	08.0	00.8	08.0	00.8	08.0	00.8	08.0	00.8	08.0	00.8	08.0	00.8
9	09.0	00.9	09.0	00.9	09.0	00.9	09.0	00.9	09.0	00.9	09.0	00.9
10	09.9	01.0	09.9	01.0	09.9	01.0	09.9	01.0	09.9	01.0	09.9	01.0
11	10.9	01.1	10.9	01.1	10.9	01.1	10.9	01.1	10.9	01.1	10.9	01.1
12	11.9	01.2	11.9	01.2	11.9	01.2	11.9	01.2	11.9	01.2	11.9	01.2
13	12.9	01.3	12.9	01.3	12.9	01.3	12.9	01.3	12.9	01.3	12.9	01.3
14	13.9	01.4	13.9	01.4	13.9	01.4	13.9	01.4	13.9	01.4	13.9	01.4
15	14.9	01.5	14.9	01.5	14.9	01.5	14.9	01.5	14.9	01.5	14.9	01.5
16	15.9	01.6	15.9	01.6	15.9	01.6	15.9	01.6	15.9	01.6	15.9	01.6
17	16.9	01.7	16.9	01.7	16.9	01.7	16.9	01.7	16.9	01.7	16.9	01.7
18	17.9	01.8	17.9	01.8	17.9	01.8	17.9	01.8	17.9	01.8	17.9	01.8
19	18.9	01.9	18.9	01.9	18.9	01.9	18.9	01.9	18.9	01.9	18.9	01.9
20	19.9	02.0	19.9	02.0	19.9	02.0	19.9	02.0	19.9	02.0	19.9	02.0
21	20.9	02.1	20.9	02.1	20.9	02.1	20.9	02.1	20.9	02.1	20.9	02.1
22	21.9	02.2	21.9	02.2	21.9	02.2	21.9	02.2	21.9	02.2	21.9	02.2
23	22.9	02.3	22.9	02.3	22.9	02.3	22.9	02.3	22.9	02.3	22.9	02.3
24	23.9	02.4	23.9	02.4	23.9	02.4	23.9	02.4	23.9	02.4	23.9	02.4
25	24.9	02.5	24.9	02.5	24.9	02.5	24.9	02.5	24.9	02.5	24.9	02.5
26	25.9	02.6	25.9	02.6	25.9	02.6	25.9	02.6	25.9	02.6	25.9	02.6
27	26.9	02.7	26.9	02.7	26.9	02.7	26.9	02.7	26.9	02.7	26.9	02.7
28	27.9	02.8	27.9	02.8	27.9	02.8	27.9	02.8	27.9	02.8	27.9	02.8
29	28.9	02.9	28.9	02.9	28.9	02.9	28.9	02.9	28.9	02.9	28.9	02.9
30	29.9	03.0	29.9	03.0	29.9	03.0	29.9	03.0	29.9	03.0	29.9	03.0
31	30.8	03.1	30.8	03.1	30.8	03.1	30.8	03.1	30.8	03.1	30.8	03.1
32	31.8	03.2	31.8	03.2	31.8	03.2	31.8	03.2	31.8	03.2	31.8	03.2
33	32.8	03.3	32.8	03.3	32.8	03.3	32.8	03.3	32.8	03.3	32.8	03.3
34	33.8	03.4	33.8	03.4	33.8	03.4	33.8	03.4	33.8	03.4	33.8	03.4
35	34.8	03.5	34.8	03.5	34.8	03.5	34.8	03.5	34.8	03.5	34.8	03.5
36	35.8	03.6	35.8	03.6	35.8	03.6	35.8	03.6	35.8	03.6	35.8	03.6
37	36.8	03.7	36.8	03.7	36.8	03.7	36.8	03.7	36.8	03.7	36.8	03.7
38	37.8	03.8	37.8	03.8	37.8	03.8	37.8	03.8	37.8	03.8	37.8	03.8
39	38.8	03.9	38.8	03.9	38.8	03.9	38.8	03.9	38.8	03.9	38.8	03.9
40	39.8	04.0	39.8	04.0	39.8	04.0	39.8	04.0	39.8	04.0	39.8	04.0
41	40.8	04.1	40.8	04.1	40.8	04.1	40.8	04.1	40.8	04.1	40.8	04.1
42	41.8	04.2	41.8	04.2	41.8	04.2	41.8	04.2	41.8	04.2	41.8	04.2
43	42.8	04.3	42.8	04.3	42.8	04.3	42.8	04.3	42.8	04.3	42.8	04.3
44	43.8	04.4	43.8	04.4	43.8	04.4	43.8	04.4	43.8	04.4	43.8	04.4
45	44.8	04.5	44.8	04.5	44.8	04.5	44.8	04.5	44.8	04.5	44.8	04.5
46	45.8	04.6	45.8	04.6	45.8	04.6	45.8	04.6	45.8	04.6	45.8	04.6
47	46.8	04.7	46.8	04.7	46.8	04.7	46.8	04.7	46.8	04.7	46.8	04.7
48	47.8	04.8	47.8	04.8	47.8	04.8	47.8	04.8	47.8	04.8	47.8	04.8
49	48.8	04.9	48.8	04.9	48.8	04.9	48.8	04.9	48.8	04.9	48.8	04.9
50	49.8	05.0	49.8	05.0	49.8	05.0	49.8	05.0	49.8	05.0	49.8	05.0
Diff.	D pt Lat.		D pt Lat.		D pt Lat.		D pt Lat.		D pt Lat.		D pt Lat.	
	7½ Point		84 Deg.		83 Deg.		82 Deg.		7½ Point		81 Deg.	

Point	6 Deg.	7 Deg.	8 Deg.	Point	9 Deg.	Dist.
Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
50.7 05.0	50.7 05.3	50.6 06.2	50.5 07.1	50.4 07.9	50.4 08.0	51
51.7 05.1	51.7 05.4	51.6 06.3	51.5 07.2	51.4 07.6	51.4 08.1	52
52.7 05.2	52.7 05.5	52.6 06.5	52.5 07.4	52.4 07.8	52.3 08.3	53
53.7 05.3	53.7 05.6	53.6 06.6	53.5 07.5	53.4 07.9	53.3 08.4	54
54.7 05.4	54.7 05.8	54.6 06.7	54.5 07.6	54.4 08.1	54.3 08.6	55
55.7 05.5	55.7 05.8	55.6 06.7	55.5 07.8	55.4 08.2	55.3 08.7	56
56.7 05.6	56.7 06.0	56.6 06.9	56.4 07.9	56.4 08.4	56.3 08.9	57
57.7 05.7	57.7 06.1	57.6 07.1	57.4 08.1	57.4 08.5	57.3 09.1	58
58.7 05.8	58.7 06.2	58.6 07.2	58.4 08.2	58.4 08.7	58.3 09.2	59
59.7 05.9	59.7 06.3	59.5 07.3	59.4 08.3	59.3 08.8	59.3 09.4	60
60.7 06.0	60.7 06.4	60.5 07.4	60.4 08.5	60.3 08.9	60.2 09.5	61
61.7 06.1	61.6 06.5	61.5 07.6	61.4 08.6	61.3 09.1	61.2 09.7	62
62.7 06.2	62.6 06.6	62.5 07.7	62.4 08.8	62.3 09.2	62.2 09.9	63
63.7 06.3	63.6 06.7	63.5 07.8	63.4 08.9	63.3 09.4	63.2 10.0	64
64.7 06.4	64.6 06.8	64.5 07.9	64.4 09.1	64.3 09.5	64.2 10.2	65
65.7 06.5	65.6 06.9	65.5 08.0	65.4 09.2	65.3 09.7	65.2 10.3	66
66.7 06.6	66.6 07.0	66.5 08.2	66.3 09.3	66.3 09.8	66.2 10.5	67
67.7 06.7	67.6 07.1	67.5 08.3	67.3 09.5	67.3 10.0	67.2 10.6	68
68.7 06.8	68.6 07.2	68.5 08.4	68.3 09.6	68.2 10.1	68.1 10.8	69
69.7 06.9	69.6 07.3	69.5 08.5	69.3 09.7	69.2 10.2	69.1 10.9	70
70.6 07.0	70.6 07.4	70.5 08.7	70.3 09.9	70.2 10.4	70.1 11.4	71
71.6 07.1	71.6 07.5	71.5 08.8	71.3 10.0	71.2 10.6	71.1 11.3	72
72.6 07.1	72.6 07.6	72.4 08.9	72.3 10.2	72.2 10.7	72.1 11.4	73
73.6 07.2	73.6 07.7	73.4 9.0	73.3 10.3	73.2 10.9	73.1 11.6	74
74.6 07.3	74.6 07.8	74.4 09.1	74.3 10.4	74.2 11.0	74.1 11.7	75
75.6 07.4	75.6 07.9	75.4 09.3	75.3 10.6	75.2 11.1	75.1 11.9	76
76.6 07.5	76.6 08.0	76.4 09.4	76.2 10.7	76.2 11.3	76.0 12.0	77
77.6 07.6	77.6 08.1	77.4 09.5	77.2 10.9	77.1 11.4	77.0 12.2	78
78.6 07.7	78.6 08.2	78.4 9.6	78.2 11.0	78.1 11.6	78.0 12.4	79
79.6 07.8	79.6 08.4	79.4 09.8	79.2 11.1	79.1 11.7	79.0 12.5	80
80.6 07.9	80.5 08.5	80.4 09.9	80.2 11.3	80.1 11.9	80.0 12.7	81
81.6 08.0	81.5 08.6	81.4 10.0	81.2 11.4	81.1 12.0	81.0 12.8	82
82.6 08.1	82.5 08.7	82.4 10.0	82.2 11.5	82.1 12.2	82.0 13.0	83
83.6 08.2	83.5 08.8	83.4 10.1	83.2 11.7	83.1 12.3	83.0 13.1	84
84.6 08.3	84.5 08.9	84.4 10.2	84.2 11.8	84.1 12.5	84.0 13.3	85
85.6 08.4	85.5 09.0	85.4 10.4	85.2 12.0	85.1 12.6	84.9 13.4	86
86.6 08.5	86.5 09.1	86.3 10.5	86.1 12.1	86.0 12.8	85.9 13.6	87
87.6 08.6	87.5 09.2	87.3 10.7	87.1 12.2	87.0 12.9	86.9 13.8	88
88.6 08.7	88.5 09.3	88.3 10.9	88.1 12.4	88.0 13.1	87.9 13.9	89
89.6 08.8	89.5 09.4	89.3 11.0	89.1 12.5	89.0 13.2	88.9 14.1	90
90.6 08.9	90.5 09.5	90.3 11.1	90.1 12.7	90.0 13.4	89.9 14.2	91
91.6 09.0	91.5 09.6	91.3 11.2	91.1 12.8	91.0 13.5	90.9 14.4	92
92.6 09.1	92.5 09.7	92.3 11.3	92.1 12.9	92.0 13.6	91.8 14.5	93
93.6 09.2	93.5 9.8	93.3 11.5	93.1 13.1	93.0 13.8	92.8 14.7	94
94.6 09.3	94.5 9.9	94.3 11.6	94.1 13.2	94.0 13.9	93.8 14.9	95
95.6 09.4	95.5 10.0	95.3 11.7	95.1 13.4	95.0 14.1	94.8 15.0	96
96.6 09.5	96.5 10.1	96.3 11.8	96.0 13.5	95.9 14.2	95.8 15.2	97
97.6 09.6	97.5 10.2	97.3 12.0	97.0 13.6	96.9 14.4	96.8 15.3	98
98.6 09.7	98.5 10.3	98.3 12.1	98.0 13.8	97.9 14.5	97.8 15.5	99
99.6 09.8	99.5 10.4	99.2 12.2	99.0 13.9	98.9 14.7	98.8 15.6	100
Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	
71 Point	84 Deg.	83 Deg.	82 Deg.	71 P. int	81 Deg.	

Lat. Deg.	Lat. Deg.	1 Point	Lat. Deg.	Lat. Deg.	Lat. Deg.	Lat. Deg.
10.000.2	11.000.2	01.000.2	12.000.2	13.000.2	14.000.2	
1 01.000.2	01.000.2	01.000.2	01.000.2	01.000.2	01.000.2	
2 02.000.3	02.000.4	02.000.4	02.000.4	02.000.4	02.000.4	
3 03.000.5	03.000.6	03.000.6	03.000.6	03.000.6	03.000.6	
4 04.000.7	04.000.8	04.000.8	04.000.8	04.000.8	04.000.8	
5 05.000.9	05.000.9	05.000.9	05.000.9	05.000.9	05.000.9	
6 06.001.0	06.001.1	06.001.1	06.001.1	06.001.1	06.001.1	
7 07.001.2	07.001.3	07.001.3	07.001.3	07.001.3	07.001.3	
8 08.001.4	08.001.5	08.001.5	08.001.5	08.001.5	08.001.5	
9 09.001.6	09.001.7	09.001.7	09.001.7	09.001.7	09.001.7	
10 10.001.7	10.001.8	10.001.8	10.001.8	10.001.8	10.001.8	
11 11.001.9	11.002.0	11.002.0	11.002.0	11.002.0	11.002.0	
12 12.002.1	12.002.2	12.002.2	12.002.2	12.002.2	12.002.2	
13 13.002.3	13.002.4	13.002.4	13.002.4	13.002.4	13.002.4	
14 14.002.5	14.002.6	14.002.6	14.002.6	14.002.6	14.002.6	
15 15.002.7	15.002.8	15.002.8	15.002.8	15.002.8	15.002.8	
16 16.002.9	16.003.0	16.003.0	16.003.0	16.003.0	16.003.0	
17 17.003.1	17.003.2	17.003.2	17.003.2	17.003.2	17.003.2	
18 18.003.3	18.003.4	18.003.4	18.003.4	18.003.4	18.003.4	
19 19.003.5	19.003.6	19.003.6	19.003.6	19.003.6	19.003.6	
20 20.003.7	20.003.8	20.003.8	20.003.8	20.003.8	20.003.8	
21 21.003.9	21.004.0	21.004.0	21.004.0	21.004.0	21.004.0	
22 22.004.1	22.004.2	22.004.2	22.004.2	22.004.2	22.004.2	
23 23.004.3	23.004.4	23.004.4	23.004.4	23.004.4	23.004.4	
24 24.004.5	24.004.6	24.004.6	24.004.6	24.004.6	24.004.6	
25 25.004.7	25.004.8	25.004.8	25.004.8	25.004.8	25.004.8	
26 26.004.9	26.005.0	26.005.0	26.005.0	26.005.0	26.005.0	
27 27.005.1	27.005.2	27.005.2	27.005.2	27.005.2	27.005.2	
28 28.005.3	28.005.4	28.005.4	28.005.4	28.005.4	28.005.4	
29 29.005.5	29.005.6	29.005.6	29.005.6	29.005.6	29.005.6	
30 30.005.7	30.005.8	30.005.8	30.005.8	30.005.8	30.005.8	
31 31.006.0	31.006.1	31.006.1	31.006.1	31.006.1	31.006.1	
32 32.006.2	32.006.3	32.006.3	32.006.3	32.006.3	32.006.3	
33 33.006.4	33.006.5	33.006.5	33.006.5	33.006.5	33.006.5	
34 34.006.6	34.006.7	34.006.7	34.006.7	34.006.7	34.006.7	
35 35.006.8	35.006.9	35.006.9	35.006.9	35.006.9	35.006.9	
36 36.007.0	36.007.1	36.007.1	36.007.1	36.007.1	36.007.1	
37 37.007.2	37.007.3	37.007.3	37.007.3	37.007.3	37.007.3	
38 38.007.4	38.007.5	38.007.5	38.007.5	38.007.5	38.007.5	
39 39.007.6	39.007.7	39.007.7	39.007.7	39.007.7	39.007.7	
40 40.007.8	40.007.9	40.007.9	40.007.9	40.007.9	40.007.9	
41 41.008.0	41.008.1	41.008.1	41.008.1	41.008.1	41.008.1	
42 42.008.2	42.008.3	42.008.3	42.008.3	42.008.3	42.008.3	
43 43.008.4	43.008.5	43.008.5	43.008.5	43.008.5	43.008.5	
44 44.008.6	44.008.7	44.008.7	44.008.7	44.008.7	44.008.7	
45 45.008.8	45.008.9	45.008.9	45.008.9	45.008.9	45.008.9	
46 46.009.0	46.009.1	46.009.1	46.009.1	46.009.1	46.009.1	
47 47.009.2	47.009.3	47.009.3	47.009.3	47.009.3	47.009.3	
48 48.009.4	48.009.5	48.009.5	48.009.5	48.009.5	48.009.5	
49 49.009.6	49.009.7	49.009.7	49.009.7	49.009.7	49.009.7	
50 50.009.8	50.009.9	50.009.9	50.009.9	50.009.9	50.009.9	
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	
80 Deg.	79 Deg.	7 Points.	78 Deg.	77 Deg.	76 Deg.	

10 Deg.	11 Deg.	1 Point	12 Deg.	13 Deg.	14 Deg.	15 Deg.
Lat. D. P.	Lat. D. P.	Lat. D. P.	Lat. D. P.	Lat. D. P.	Lat. D. P.	Lat. D. P.
51	50.2 08.8	50.9 09.7	50.1 09.6	42.7 11.9	49.5 12.3	51
52	51.2 09.6	51.0 09.9	50.9 10.8	50.7 12.7	50.5 12.6	52
53	52.2 09.2	52.0 10.1	51.8 11.0	51.6 13.9	51.4 12.8	53
54	53.2 09.4	53.0 10.3	52.0 10.9	52.0 11.2	52.6 12.4	54
55	54.2 09.5	54.0 10.4	53.9 10.7	53.8 11.4	53.6 12.4	55
56	55.1 09.7	55.0 10.7	54.9 10.9	54.8 11.6	54.5 12.6	56
57	56.1 09.9	56.0 10.8	55.9 11.1	55.8 11.8	55.5 12.8	57
58	57.1 10.1	56.9 11.1	56.9 11.3	56.7 12.1	56.5 13.0	58
59	58.1 10.2	57.9 11.3	57.9 11.4	57.7 12.3	57.5 13.2	59
60	59.1 10.4	58.9 11.4	58.8 11.7	58.7 12.5	58.5 13.3	60
61	60.1 10.6	59.9 11.6	59.8 11.9	59.7 12.7	59.4 13.7	61
62	61.1 10.8	60.9 11.8	60.8 12.1	60.6 12.9	60.4 13.9	62
63	62.0 10.9	61.8 12.0	61.7 12.3	61.6 13.1	61.4 14.1	63
64	63.0 11.1	62.8 12.2	62.7 12.5	62.6 13.3	62.3 14.4	64
65	64.0 11.3	63.8 12.4	63.7 12.7	63.6 13.5	63.3 14.6	65
66	65.0 11.5	64.8 12.6	64.7 12.9	64.6 13.7	64.3 14.8	66
67	66.0 11.6	65.8 12.8	65.7 13.1	65.5 13.9	65.3 15.1	67
68	67.0 11.8	66.7 13.0	66.7 13.3	66.5 14.1	66.2 15.3	68
69	68.0 12.0	67.7 13.2	67.7 13.5	67.5 14.3	67.2 15.5	69
70	68.9 12.2	68.7 13.4	68.7 13.7	68.5 14.5	68.2 15.7	70
71	69.9 12.3	69.7 13.5	69.6 13.9	69.4 14.8	69.2 16.0	71
72	70.9 12.5	70.7 13.7	70.6 14.0	70.4 15.0	70.1 16.2	72
73	71.9 12.7	71.7 13.9	71.6 14.2	71.4 15.2	71.1 16.4	73
74	72.9 12.8	72.6 14.1	72.6 14.4	72.4 15.4	72.1 16.6	74
75	73.9 13.0	73.6 14.3	73.6 14.6	73.4 15.6	73.1 16.8	75
76	74.8 13.2	74.6 14.5	74.5 14.8	74.3 15.8	74.0 17.1	76
77	75.8 13.4	75.6 14.7	75.5 15.0	75.3 16.0	75.0 17.3	77
78	76.8 13.5	76.6 14.9	76.5 15.2	76.3 16.2	76.0 17.5	78
79	77.8 13.7	77.5 15.1	77.5 15.4	77.3 16.4	77.0 17.8	79
80	78.8 13.9	78.5 15.3	78.5 15.6	78.2 16.6	77.9 18.0	80
81	79.8 14.1	79.5 15.5	79.4 15.8	79.2 16.8	78.9 18.1	81
82	80.8 14.2	80.5 15.6	80.4 16.0	80.2 17.0	79.9 18.4	82
83	81.7 14.4	81.5 15.8	81.4 16.2	81.2 17.2	80.9 18.7	83
84	82.7 14.5	82.5 16.0	82.4 16.4	82.2 17.5	81.8 18.9	84
85	83.7 14.8	83.4 16.2	83.4 16.6	83.1 17.7	82.8 19.1	85
86	84.7 14.9	84.4 16.4	84.3 16.8	84.1 17.9	83.8 19.3	86
87	85.7 15.1	85.4 16.6	85.3 17.0	85.1 18.1	84.8 19.6	87
88	86.7 15.3	86.4 16.8	86.3 17.2	86.1 18.3	85.7 19.8	88
89	87.6 15.4	87.4 17.0	87.3 17.4	87.1 18.5	86.7 20.0	89
90	88.6 15.6	88.3 17.2	88.3 17.6	88.0 18.7	87.7 20.1	90
91	89.6 15.8	89.3 17.4	89.2 17.8	89.0 18.9	88.7 20.5	91
92	90.6 16.0	90.3 17.6	90.1 17.9	90.0 19.1	89.6 20.7	92
93	91.6 16.1	91.3 17.7	91.2 18.1	91.0 19.3	90.6 20.9	93
94	92.6 16.3	92.3 17.9	92.2 18.3	91.9 19.5	91.6 21.1	94
95	93.5 16.5	93.2 18.1	93.2 18.5	92.0 19.7	92.6 21.4	95
96	94.5 16.7	94.2 18.3	94.2 18.7	93.9 20.0	93.6 21.6	96
97	95.5 16.8	95.2 18.5	95.1 18.9	94.9 20.2	94.6 21.8	97
98	96.5 17.0	96.2 18.7	96.1 19.1	95.9 20.4	95.6 22.0	98
99	97.5 17.2	97.2 18.9	97.1 19.3	96.8 20.6	96.5 22.3	99
100	98.5 17.4	98.2 19.1	98.1 19.5	97.8 20.8	97.4 22.5	100
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.
80 Deg.	79 Deg.	7 Points	78 Deg.	77 Deg.	76 Deg.	75

Dif	14 Point	15 Deg.	16 Deg.	14 Point	15 Deg.	16 Deg.	Dif
	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
1	01.0 00.1	01.0 00.3	01.0 00.3	01.0 00.3	01.0 00.3	00.9 00.3	1
2	01.9 00.3	01.9 00.5	01.9 00.5	01.9 00.6	01.9 00.6	01.9 00.6	2
3	02.9 00.7	02.9 00.8	02.9 00.8	02.9 00.9	02.9 00.9	02.8 00.9	3
4	03.9 01.1	03.9 01.0	03.8 01.1	03.8 01.2	03.8 01.2	03.8 01.2	4
5	04.8 01.2	04.8 01.3	04.7 01.4	04.8 01.3	04.8 01.3	04.8 01.3	5
6	05.8 01.5	05.8 01.5	05.8 01.6	05.8 01.7	05.7 01.7	05.7 01.8	6
7	06.8 01.7	06.8 01.8	06.8 01.9	06.8 02.0	06.7 02.0	06.7 02.1	7
8	07.8 01.9	07.7 02.1	07.7 02.2	07.7 02.3	07.6 02.3	07.6 02.5	8
9	08.7 02.2	08.7 02.3	08.6 02.5	08.6 02.6	08.6 02.6	08.6 02.8	9
10	09.7 02.4	09.7 02.6	09.6 02.8	09.6 02.9	09.6 02.9	09.5 03.1	10
11	10.7 02.8	10.6 02.8	10.6 03.0	10.5 03.2	10.5 03.2	10.5 03.4	11
12	11.6 02.9	11.6 03.1	11.5 03.3	11.5 03.5	11.5 03.5	11.4 03.7	12
13	12.6 03.2	12.6 03.4	12.5 03.6	12.4 03.8	12.4 03.8	12.4 04.0	13
14	13.6 03.4	13.5 03.6	13.5 03.9	13.4 04.1	13.4 04.1	13.3 04.3	14
15	14.5 03.6	14.5 03.9	14.4 04.1	14.4 04.4	14.3 04.4	14.3 04.6	15
16	15.5 04.0	15.5 04.1	15.4 4.4	15.3 04.6	15.3 04.7	15.2 04.9	16
17	16.5 04.1	16.4 04.4	16.3 04.7	16.3 04.9	16.3 05.0	16.2 05.2	17
18	17.5 04.4	17.4 04.7	17.3 05.0	17.2 05.2	17.2 05.3	17.1 05.6	18
19	18.4 04.6	18.4 04.9	18.3 05.2	18.2 05.5	18.2 05.5	18.1 05.9	19
20	19.4 04.9	19.3 05.2	19.2 05.5	19.1 05.8	19.1 05.8	19.0 06.2	20
21	20.4 05.1	20.3 05.4	20.2 05.8	20.1 06.1	20.1 06.1	20.0 06.5	21
22	21.3 05.3	21.2 05.7	21.1 06.1	21.0 06.4	21.0 06.4	20.9 06.8	22
23	22.3 05.6	22.2 06.0	22.1 06.3	22.0 06.7	22.0 06.7	21.9 07.1	23
24	23.3 05.8	23.2 06.2	23.1 06.6	23.0 06.8	22.9 07.0	22.8 07.4	24
25	24.2 06.0	24.1 06.5	24.0 6.9	23.9 07.3	23.9 07.3	23.8 07.7	25
26	25.2 06.3	25.1 06.7	24.9 07.2	24.9 07.5	24.9 07.6	24.7 08.0	26
27	26.2 06.5	26.1 07.0	25.9 07.4	25.8 07.8	25.8 07.9	25.7 08.3	27
28	27.2 06.8	27.0 07.2	26.9 07.7	26.8 08.1	26.8 08.2	26.6 08.6	28
29	28.1 07.0	28.0 07.5	27.8 08.0	27.8 08.4	27.7 08.5	27.6 09.0	29
30	29.1 07.2	29.0 07.8	28.8 08.2	28.7 08.7	28.7 08.8	28.5 09.2	30
31	30.1 07.5	29.9 08.0	29.8 08.5	29.7 09.0	29.6 09.1	29.5 09.6	31
32	31.0 07.9	30.9 08.3	30.7 08.8	30.6 09.3	30.6 09.3	30.4 10.0	32
33	31.0 08.0	31.0 08.5	31.7 09.1	31.6 09.6	31.6 09.6	31.4 10.2	33
34	32.0 08.2	32.0 08.8	32.7 09.4	32.5 09.9	32.5 09.9	32.3 10.5	34
35	33.0 08.5	33.0 09.0	32.6 09.6	33.5 10.1	33.5 10.2	33.3 10.8	35
36	34.0 08.7	34.0 09.3	34.6 09.9	34.4 10.4	34.4 10.5	34.2 11.1	36
37	35.0 09.0	35.0 09.6	35.6 10.2	35.4 10.7	35.4 10.8	35.2 11.4	37
38	36.0 09.2	36.0 09.8	36.5 10.5	36.4 11.0	36.3 11.1	36.1 11.7	38
39	37.0 09.5	37.0 10.1	37.5 10.7	37.3 11.3	37.3 11.4	37.1 12.0	39
40	38.0 09.7	38.0 10.2	38.4 11.0	38.3 11.6	38.2 11.7	38.0 12.4	40
41	39.8 10.0	39.6 10.6	39.7 11.2	39.2 11.9	39.2 12.0	39.0 12.7	41
42	40.7 10.2	40.6 10.9	40.4 11.6	40.1 12.2	40.2 12.3	39.9 13.0	42
43	41.7 10.4	41.5 11.1	41.3 11.8	41.1 12.5	41.1 12.6	40.9 13.3	43
44	42.7 10.7	42.5 11.5	42.3 12.1	42.1 12.8	42.1 12.9	41.8 13.6	44
45	43.6 10.9	43.5 11.6	43.2 12.4	43.1 13.1	43.0 13.1	42.8 13.9	45
46	44.6 11.1	44.4 11.9	44.2 12.7	44.0 13.3	44.0 13.4	43.7 14.2	46
47	45.6 11.4	45.4 12.2	45.2 12.9	45.0 13.6	44.9 13.7	44.7 14.5	47
48	46.6 11.7	46.4 12.4	46.2 13.2	45.9 13.9	45.9 14.0	45.6 14.8	48
49	47.5 11.9	47.3 12.7	47.1 13.5	46.9 14.2	46.9 14.3	46.6 15.1	49
50	48.5 12.1	48.3 12.9	48.1 13.8	47.8 14.5	47.8 14.6	47.5 15.4	50
Dif	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dif
	6 Point	75 Deg.	74 Deg.	6 Point	73 Deg.	72 Deg.	

Diff	19 Deg.	1 Point	20 Deg.	1 Deg.	21 Deg.	2 Points	22 Deg.	2 Points
	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep
1	00.9 00.3	00.9 00.3	00.9 00.3	00.9 00.4	00.9 00.4	00.9 00.4	00.9 00.4	00.9 00.4
2	01.9 00.6	01.9 00.7	01.9 00.7	01.9 00.7	01.9 00.7	01.9 00.7	01.9 00.7	01.9 00.7
3	02.8 01.0	02.8 01.0	02.8 01.0	02.8 01.1	02.8 01.1	02.8 01.1	02.8 01.1	02.8 01.1
4	03.8 01.3	03.8 01.3	03.8 01.4	03.7 01.4	03.7 01.4	03.7 01.4	03.7 01.4	03.7 01.4
5	04.7 01.6	04.7 01.7	04.7 01.7	04.7 01.8	04.7 01.8	04.7 01.8	04.7 01.8	04.7 01.8
6	05.7 01.9	05.6 02.0	05.6 02.0	05.6 02.1	05.6 02.1	05.6 02.1	05.6 02.1	05.6 02.1
7	06.6 02.3	06.6 02.4	06.6 02.4	06.5 02.5	06.5 02.5	06.5 02.5	06.5 02.5	06.5 02.5
8	07.6 02.6	07.5 02.7	07.5 02.7	07.5 02.9	07.4 03.0	07.4 03.0	07.4 03.0	07.4 03.0
9	08.5 02.9	08.5 03.0	08.5 03.1	08.4 03.2	08.3 03.4	08.3 03.4	08.3 03.4	08.3 03.4
10	09.5 03.3	09.4 03.4	09.4 03.4	09.3 03.6	09.2 03.7	09.2 03.7	09.2 03.7	09.2 03.7
11	10.4 03.6	10.4 03.7	10.3 03.8	10.3 03.9	10.2 04.1	10.2 04.1	10.2 04.1	10.2 04.1
12	11.3 03.9	11.3 04.0	11.3 04.1	11.2 04.3	11.1 04.5	11.1 04.5	11.1 04.5	11.1 04.5
13	12.3 04.2	12.2 04.4	12.2 04.4	12.1 04.7	12.0 04.9	12.0 04.9	12.0 04.9	12.0 04.9
14	13.2 04.6	13.2 04.7	13.2 04.8	13.1 05.0	13.0 05.2	12.9 05.4	12.9 05.4	12.9 05.4
15	14.2 04.9	14.1 05.1	14.1 05.1	14.0 05.4	13.9 05.6	13.9 05.6	13.9 05.6	13.9 05.6
16	15.1 05.2	15.1 05.3	15.0 05.4	14.9 05.7	14.8 06.0	14.8 06.1	14.8 06.1	14.8 06.1
17	16.1 05.5	16.0 05.7	16.0 05.8	15.9 06.1	15.8 06.4	15.7 06.5	15.7 06.5	15.7 06.5
18	17.0 05.9	16.9 06.1	16.9 06.3	16.8 06.4	16.7 06.7	16.6 06.8	16.6 06.8	16.6 06.8
19	18.0 06.1	17.9 06.4	17.9 06.5	17.7 06.8	17.6 07.1	17.6 07.3	17.6 07.3	17.6 07.3
20	18.9 06.5	18.8 06.7	18.8 06.8	18.7 07.2	18.5 07.5	18.5 07.6	18.5 07.6	18.5 07.6
21	19.9 06.8	19.8 07.1	19.7 07.2	19.6 07.5	19.5 07.9	19.4 08.0	19.4 08.0	19.4 08.0
22	20.8 07.2	20.7 07.4	20.7 07.5	20.5 07.9	20.4 08.2	20.3 08.4	20.3 08.4	20.3 08.4
23	21.7 07.5	21.7 07.7	21.6 07.9	21.5 08.2	21.3 08.6	21.2 08.8	21.2 08.8	21.2 08.8
24	22.7 07.8	22.6 08.1	22.5 08.2	22.4 08.6	22.2 09.0	22.1 09.2	22.1 09.2	22.1 09.2
25	23.6 08.1	23.5 08.4	23.5 08.5	23.3 09.0	23.2 09.4	23.1 09.6	23.1 09.6	23.1 09.6
26	24.6 08.5	24.5 08.8	24.4 08.9	24.3 09.3	24.1 09.7	24.0 09.9	24.0 09.9	24.0 09.9
27	25.5 08.8	25.4 09.1	25.4 09.2	25.2 09.7	25.0 10.1	24.9 10.3	24.9 10.3	24.9 10.3
28	26.5 09.1	26.4 09.4	26.3 09.6	26.1 10.0	26.0 10.5	25.9 10.7	25.9 10.7	25.9 10.7
29	27.4 09.4	27.3 09.8	27.2 09.9	27.1 10.4	26.9 10.9	26.8 11.1	26.8 11.1	26.8 11.1
30	28.4 09.8	28.2 10.1	28.2 10.2	28.0 10.7	27.8 11.2	27.7 11.5	27.7 11.5	27.7 11.5
31	29.3 10.1	29.2 10.4	29.1 10.5	28.9 11.1	28.7 11.6	28.6 11.9	28.6 11.9	28.6 11.9
32	30.3 10.4	30.1 10.8	30.1 10.9	29.1 11.5	29.7 12.0	29.6 12.2	29.6 12.2	29.6 12.2
33	31.2 10.7	31.1 11.1	31.0 11.2	30.8 11.8	30.6 12.4	30.5 12.6	30.5 12.6	30.5 12.6
34	32.1 11.1	32.0 11.5	31.9 11.6	31.7 12.2	31.5 12.7	31.4 13.0	31.4 13.0	31.4 13.0
35	33.1 11.4	33.0 11.8	32.9 12.0	32.7 12.5	32.4 13.1	32.3 13.4	32.3 13.4	32.3 13.4
36	34.0 11.7	33.9 12.1	33.8 12.3	33.6 12.9	33.4 13.5	33.3 13.8	33.3 13.8	33.3 13.8
37	35.0 12.1	34.8 12.5	34.8 12.6	34.5 13.3	34.3 13.9	34.2 14.2	34.2 14.2	34.2 14.2
38	35.9 12.4	35.8 12.8	35.7 13.0	35.5 13.6	35.2 14.2	35.1 14.5	35.1 14.5	35.1 14.5
39	36.9 12.6	36.7 13.1	36.6 13.3	36.4 14.0	36.2 14.6	36.0 14.9	36.0 14.9	36.0 14.9
40	37.8 13.0	37.7 13.5	37.6 13.7	37.3 14.3	37.1 15.0	36.9 15.3	36.9 15.3	36.9 15.3
41	38.8 13.3	38.6 13.8	38.5 14.0	38.3 14.7	38.0 15.3	37.9 15.7	37.9 15.7	37.9 15.7
42	39.7 13.7	39.5 14.1	39.5 14.4	39.2 15.1	38.9 15.7	38.8 16.1	38.8 16.1	38.8 16.1
43	40.7 14.0	40.5 14.5	40.4 14.7	40.1 15.4	39.9 16.1	39.7 16.5	39.7 16.5	39.7 16.5
44	41.6 14.3	41.4 14.8	41.3 15.0	41.1 15.8	40.8 16.5	40.6 16.8	40.6 16.8	40.6 16.8
45	42.6 14.6	42.4 15.2	42.3 15.4	42.0 16.1	41.7 16.8	41.6 17.2	41.6 17.2	41.6 17.2
46	43.5 15.0	43.3 15.5	43.2 15.7	42.9 16.5	42.6 17.2	42.5 17.6	42.5 17.6	42.5 17.6
47	44.4 15.3	44.2 15.8	44.2 16.1	43.9 16.8	43.6 17.6	43.4 18.0	43.4 18.0	43.4 18.0
48	45.4 15.6	45.2 16.2	45.1 16.4	44.8 17.2	44.5 18.0	44.3 18.4	44.3 18.4	44.3 18.4
49	46.3 15.9	46.1 16.5	46.0 16.8	45.7 17.6	45.4 18.3	45.3 18.7	45.3 18.7	45.3 18.7
50	47.3 16.3	47.1 16.8	47.0 17.1	46.7 17.9	46.4 18.7	46.2 19.1	46.2 19.1	46.2 19.1
Diff	Den Lat.	Dep Lat.	Den Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.
	71 Deg.	61 Point	70 Deg.	69 Deg.	68 deg.	6 Points		

19 Deg.	19 Points	20 Deg.	21 Deg.	22 Deg.	2 Points	D
Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	D
41	42.2 16.6	42.9 17.4	44.6 18.2	46.3 19.1	48.0 19.9	51
42	43.2 16.9	43.9 17.8	45.6 18.6	47.3 19.4	49.0 20.3	52
43	44.2 17.3	44.9 18.1	46.6 19.0	48.3 19.8	50.0 20.7	53
44	45.1 17.6	45.7 18.5	47.5 19.3	49.1 20.2	50.8 21.0	54
45	46.0 17.9	46.5 18.8	48.4 19.7	50.0 20.6	51.7 21.4	55
46	46.9 18.2	47.3 19.2	49.3 20.1	50.9 21.0	52.6 21.8	56
47	47.8 18.6	48.1 19.5	50.2 20.4	51.8 21.3	53.5 22.2	57
48	48.7 18.9	48.9 19.8	51.1 20.8	52.7 21.7	54.4 22.6	58
49	49.6 19.2	49.7 20.2	52.0 21.1	53.6 22.1	55.3 23.0	59
50	50.5 19.5	50.5 20.5	52.9 21.5	54.5 22.5	56.2 23.4	60
51	51.4 19.9	51.3 20.9	53.8 21.9	55.4 22.8	57.1 23.8	61
52	52.3 20.2	52.1 21.2	54.7 22.2	56.3 23.2	58.0 24.2	62
53	53.2 20.5	52.9 21.5	55.6 22.5	57.2 23.6	58.9 24.6	63
54	54.1 20.8	53.7 21.9	56.5 22.9	58.1 24.0	59.8 25.0	64
55	55.0 21.2	54.6 22.2	57.4 23.2	59.0 24.3	60.7 25.4	65
56	55.9 21.5	55.5 22.6	58.3 23.6	60.0 24.7	61.6 25.8	66
57	56.8 21.8	56.4 22.9	59.2 24.0	60.9 25.1	62.5 26.2	67
58	57.7 22.2	57.3 23.3	60.1 24.4	61.8 25.5	63.4 26.6	68
59	58.6 22.5	58.1 23.7	61.0 24.8	62.7 25.9	64.3 27.0	69
60	59.5 22.9	59.0 24.1	61.9 25.2	63.6 26.3	65.2 27.4	70
61	60.4 23.2	60.0 24.5	62.8 25.6	64.5 26.7	66.1 27.8	71
62	61.3 23.6	60.9 24.9	63.7 26.0	65.4 27.1	67.0 28.2	72
63	62.2 23.9	61.8 25.3	64.6 26.4	66.3 27.5	67.9 28.6	73
64	63.1 24.3	62.7 25.7	65.5 26.8	67.2 27.9	68.8 29.0	74
65	64.0 24.6	63.6 26.1	66.4 27.2	68.1 28.3	69.7 29.4	75
66	64.9 25.0	64.5 26.5	67.3 27.6	69.0 28.7	70.6 29.8	76
67	65.8 25.3	65.4 26.9	68.2 28.0	70.0 29.1	71.5 30.2	77
68	66.7 25.7	66.3 27.3	69.1 28.4	70.9 29.5	72.4 30.6	78
69	67.6 26.0	67.2 27.7	70.0 28.8	71.8 29.9	73.3 31.0	79
70	68.5 26.4	68.1 28.1	70.9 29.2	72.7 30.3	74.2 31.4	80
71	69.4 26.8	69.0 28.5	71.8 29.6	73.6 30.7	75.1 31.8	81
72	70.3 27.1	70.0 28.9	72.7 30.0	74.5 31.1	76.0 32.2	82
73	71.2 27.5	70.9 29.3	73.6 30.4	75.4 31.5	76.9 32.6	83
74	72.1 27.9	71.8 29.7	74.5 30.8	76.3 31.9	77.8 33.0	84
75	73.0 28.2	72.7 30.1	75.4 31.2	77.2 32.3	78.7 33.4	85
76	73.9 28.6	73.6 30.5	76.3 31.6	78.1 32.7	79.6 33.8	86
77	74.8 29.0	74.5 30.9	77.2 32.0	79.0 33.1	80.5 34.2	87
78	75.7 29.3	75.4 31.3	78.1 32.4	80.0 33.5	81.4 34.6	88
79	76.6 29.7	76.3 31.7	79.0 32.8	80.9 33.9	82.3 35.0	89
80	77.5 30.1	77.2 32.1	80.0 33.2	81.8 34.3	83.2 35.4	90
81	78.4 30.4	78.1 32.5	80.9 33.6	82.7 34.7	84.1 35.8	91
82	79.3 30.8	79.0 32.9	81.8 34.0	83.6 35.1	85.0 36.2	92
83	80.2 31.2	80.0 33.3	82.7 34.4	84.5 35.5	85.9 36.6	93
84	81.1 31.5	80.9 33.7	83.6 34.8	85.4 35.9	86.8 37.0	94
85	82.0 31.9	81.8 34.1	84.5 35.2	86.3 36.3	87.7 37.4	95
86	82.9 32.3	82.7 34.5	85.4 35.6	87.2 36.7	88.6 37.8	96
87	83.8 32.6	83.6 34.9	86.3 36.0	88.1 37.2	89.5 38.2	97
88	84.7 33.0	84.5 35.3	87.2 36.4	89.0 37.6	90.4 38.6	98
89	85.6 33.4	85.4 35.7	88.1 36.8	90.0 38.0	91.3 39.0	99
90	86.5 33.8	86.3 36.1	89.0 37.2	90.9 38.4	92.2 39.4	100
91	87.4 34.2	87.2 36.5	90.0 37.6	91.8 38.8		
92	88.3 34.6	88.1 36.9	90.9 38.0	92.7 39.2		
93	89.2 35.0	89.0 37.3	91.8 38.4			
94	90.1 35.4	89.9 37.7	92.7 38.8			
95	91.0 35.8	90.8 38.1	93.6 39.2			
96	91.9 36.2	91.7 38.5	94.5 39.6			
97	92.8 36.6	92.6 38.9	95.4 40.0			
98	93.7 37.0	93.5 39.3	96.3 40.4			
99	94.6 37.4	94.4 39.7	97.2 40.8			
100	95.5 37.8	95.3 40.1	98.1 41.2			
Dep. Lar.	Dep. Lar.	Dep. Lar.	Dep. Lar.	Dep. Lar.	Dep. Lar.	D
71 Deg.	61 Points	70 Deg.	69 Deg.	68 Deg.	6 Points	D

Diff	23 Deg.	24 Deg.	25 Deg.	26 Point	26 Deg.	27 Deg.	Diff
	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
1	00.9 00.4	00.9 00.4	00.9 00.4	00.9 00.4	00.9 00.4	00.9 00.4	1
2	01.8 00.8	01.8 00.8	01.8 00.8	01.8 00.9	01.8 00.9	01.8 00.9	2
3	02.8 01.2	02.7 01.2	02.7 01.3	02.7 01.3	02.7 01.3	02.7 01.4	3
4	03.7 01.6	03.6 01.6	03.6 01.7	03.6 01.7	03.6 01.7	03.6 01.8	4
5	04.6 01.9	04.6 02.0	04.5 02.1	04.5 02.1	04.5 02.2	04.5 02.3	5
6	05.5 02.3	05.5 02.4	05.4 02.5	05.4 02.6	05.4 02.6	05.3 02.7	6
7	06.4 02.7	06.4 02.8	06.3 03.0	06.3 03.0	06.3 03.1	06.3 03.2	7
8	07.4 03.1	07.3 03.2	07.2 03.4	07.2 03.4	07.2 03.5	07.1 03.6	8
9	08.3 03.5	08.2 03.7	08.1 03.8	08.1 03.8	08.1 03.9	08.0 04.1	9
10	09.2 03.9	09.1 04.1	09.0 04.2	09.0 04.3	09.0 04.4	08.9 04.5	10
11	10.1 04.3	10.0 04.5	10.0 04.6	09.9 04.7	09.9 04.8	09.8 05.0	11
12	11.0 04.7	11.0 04.9	10.9 05.1	10.8 05.1	10.8 05.3	10.7 05.4	12
13	12.0 05.1	11.9 05.3	11.8 05.5	11.7 05.6	11.7 05.7	11.6 05.8	13
14	12.9 05.5	12.8 05.7	12.7 05.9	12.7 05.9	12.6 06.2	12.5 06.4	14
15	13.8 05.9	13.7 06.1	13.6 06.3	13.6 06.4	13.5 06.6	13.4 06.8	15
16	14.7 06.3	14.6 06.5	14.5 06.8	14.5 06.6	14.4 07.0	14.3 07.3	16
17	15.6 06.6	15.5 06.9	15.4 07.2	15.4 07.3	15.3 07.4	15.1 07.7	17
18	16.6 07.0	16.4 07.3	16.3 07.6	16.3 07.7	16.2 07.9	16.0 08.2	18
19	17.5 07.4	17.4 07.7	17.2 08.0	17.2 08.1	17.1 08.3	16.9 08.6	19
20	18.4 07.8	18.3 08.1	18.1 08.4	18.1 08.5	18.0 08.8	17.8 09.1	20
21	19.3 08.2	19.2 08.5	19.0 08.9	19.0 09.0	18.9 09.2	18.7 09.5	21
22	20.2 08.6	20.1 08.9	19.9 09.3	19.9 09.4	19.8 09.9	19.6 10.0	22
23	21.2 09.0	21.0 09.3	20.8 09.7	20.8 09.8	20.7 10.1	20.5 10.4	23
24	22.1 09.4	21.9 09.8	21.7 10.1	21.7 10.3	21.6 10.5	21.4 10.9	24
25	23.0 09.8	22.8 10.2	22.7 10.6	22.6 10.7	22.5 11.0	22.3 11.3	25
26	23.9 10.2	23.7 10.6	23.6 11.0	23.5 11.1	23.4 11.4	23.2 11.8	26
27	24.8 10.5	24.7 11.0	24.5 11.4	24.4 11.5	24.3 11.8	24.1 12.3	27
28	25.8 10.9	25.6 11.4	25.4 11.8	25.3 12.1	25.2 12.3	24.9 12.7	28
29	26.7 11.3	26.5 11.8	26.3 12.3	26.2 12.4	26.1 12.7	25.8 13.2	29
30	27.6 11.7	27.4 12.2	27.2 12.7	27.1 12.8	27.0 13.1	26.7 13.6	30
31	28.5 12.1	28.3 12.6	28.1 13.1	28.0 13.3	27.9 13.6	27.6 14.1	31
32	29.5 12.5	29.2 13.0	29.0 13.5	28.9 13.7	28.8 14.0	28.5 14.5	32
33	30.4 12.9	30.1 13.4	29.9 13.9	29.8 14.1	29.7 14.4	29.4 15.0	33
34	31.3 13.3	31.1 13.8	30.8 14.4	30.7 14.5	30.6 14.9	30.3 15.4	34
35	32.2 13.7	32.0 14.2	31.7 14.8	31.6 15.0	31.5 15.3	31.2 15.9	35
36	33.1 14.1	32.9 14.6	32.6 15.2	32.5 15.4	32.4 15.8	32.1 16.3	36
37	34.1 14.4	33.8 15.0	33.5 15.6	33.4 15.8	33.2 16.2	33.0 16.8	37
38	35.0 14.8	34.7 15.4	34.4 16.0	34.3 16.2	34.1 16.6	33.9 17.2	38
39	35.9 15.2	35.6 15.9	35.3 16.4	35.3 16.7	35.0 17.1	34.7 17.7	39
40	36.8 15.6	36.5 16.3	36.2 16.9	36.2 17.1	35.9 17.5	35.6 18.2	40
41	37.7 16.0	37.5 16.7	37.2 17.3	37.1 17.5	36.8 18.0	36.4 18.6	41
42	38.7 16.4	38.4 17.1	38.1 17.7	38.0 18.0	37.7 18.4	37.4 19.1	42
43	39.6 16.8	39.3 17.5	39.0 18.2	38.9 18.4	38.6 18.8	38.3 19.5	43
44	40.5 17.2	40.2 17.9	39.9 18.6	39.8 18.8	39.5 19.3	39.2 20.0	44
45	41.4 17.6	41.1 18.3	40.8 19.0	40.7 19.2	40.4 19.7	40.1 20.4	45
46	42.3 18.0	42.0 18.7	41.7 19.4	41.6 19.7	41.3 20.2	41.0 20.9	46
47	43.3 18.4	42.9 19.1	42.6 19.9	42.5 20.1	42.2 20.6	41.9 21.3	47
48	44.2 18.8	43.8 19.5	43.5 20.3	43.4 20.5	43.1 21.0	42.8 21.8	48
49	45.1 19.2	44.8 19.9	44.4 20.7	44.2 20.9	44.0 21.5	43.7 22.2	49
50	46.0 19.5	45.7 20.3	45.3 21.1	45.2 21.4	44.9 21.8	44.5 22.7	50
Diff	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Diff
	67 Deg.	66 Deg.	65 Deg.	64 Point	64 Deg.	63 Deg.	

	23 Deg.	24 Deg.	25 Deg.	25 Point	26 Deg.	27 Deg.	
Diff.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Diff.
51	46.9 19.9	46.6 20.7	46.2 21.5	46.1 21.8	45.8 22.3	45.4 22.2	51
52	47.9 20.3	47.5 21.1	47.1 22.0	47.0 22.2	46.7 22.8	46.3 23.6	52
53	48.8 20.4	48.4 21.3	48.0 22.4	47.9 22.7	47.6 23.2	47.2 24.1	53
54	49.7 21.1	49.3 22.0	48.9 22.8	48.8 23.1	48.5 23.7	48.1 24.5	54
55	50.6 21.5	50.2 22.4	49.8 23.2	49.7 23.5	49.4 24.1	49.0 25.0	55
56	51.5 21.9	51.2 22.8	50.7 23.7	50.6 23.9	50.3 24.5	49.9 25.4	56
57	52.5 22.3	52.1 23.2	51.7 24.1	51.5 24.4	51.2 25.0	50.8 25.9	57
58	53.4 22.7	53.0 23.6	52.6 24.5	52.4 24.8	52.1 25.4	51.7 26.3	58
59	54.3 23.0	53.9 24.0	53.5 24.9	53.3 25.2	53.0 25.9	52.6 26.8	59
60	55.2 23.4	54.8 24.4	54.4 25.4	54.2 25.6	53.9 26.3	53.5 27.2	60
61	56.1 23.8	55.7 24.8	55.3 25.8	55.1 26.1	54.8 26.7	54.4 27.7	61
62	57.1 24.2	56.6 25.2	56.2 26.2	56.0 26.5	55.7 27.2	55.2 28.1	62
63	58.0 24.6	57.5 25.6	57.1 26.6	56.9 26.9	56.6 27.6	56.1 28.6	63
64	58.9 25.0	58.5 26.0	58.0 27.0	57.9 27.4	57.5 28.0	57.0 29.1	64
65	59.8 25.4	59.4 26.4	58.9 27.5	58.8 27.8	58.4 28.5	57.9 29.5	65
66	60.7 25.8	60.3 26.8	59.8 27.9	59.7 28.2	59.3 28.9	58.8 30.0	66
67	61.7 26.2	61.2 27.2	60.7 28.3	60.6 28.6	60.2 29.4	59.7 30.4	67
68	62.6 26.6	62.1 27.7	61.6 28.7	61.5 29.1	61.1 29.8	60.6 30.9	68
69	63.5 27.0	63.0 28.1	62.5 29.2	62.4 29.5	62.0 30.2	61.5 31.3	69
70	64.4 27.3	63.9 28.5	63.4 29.6	63.3 29.9	62.9 30.7	62.4 31.8	70
71	65.4 27.7	64.9 28.9	64.3 30.0	64.2 30.4	63.8 31.1	63.3 32.2	71
72	66.3 28.1	65.8 29.3	65.2 30.4	65.1 30.8	64.7 31.6	64.2 32.7	72
73	67.2 28.5	66.7 29.7	66.2 30.8	66.0 31.2	65.6 32.0	65.0 33.1	73
74	68.1 28.9	67.6 30.1	67.1 31.3	66.9 31.6	66.5 32.4	65.9 33.6	74
75	69.0 29.3	68.5 30.5	68.0 31.7	67.8 32.1	67.4 32.9	66.8 34.1	75
76	70.0 29.7	69.4 30.9	68.9 32.1	68.7 32.5	68.3 33.3	67.7 34.5	76
77	70.9 30.1	70.3 31.3	69.8 32.5	69.6 32.9	69.2 33.7	68.6 35.0	77
78	71.8 30.5	71.2 31.7	70.7 33.0	70.5 33.3	70.1 34.2	69.5 35.4	78
79	72.7 30.9	72.2 32.1	71.6 33.4	71.4 33.8	71.0 34.6	70.4 35.9	79
80	73.6 31.3	73.1 32.5	72.5 33.8	72.3 34.2	71.9 35.1	71.3 36.3	80
81	74.6 31.6	74.0 32.9	73.4 34.2	73.2 34.6	72.8 35.5	72.2 36.8	81
82	75.5 32.0	74.9 33.3	74.3 34.7	74.1 35.1	73.7 35.9	73.1 37.2	82
83	76.4 32.4	75.8 33.8	75.2 35.1	75.0 35.5	74.6 36.4	74.0 37.7	83
84	77.3 32.8	76.7 34.2	76.1 35.5	75.9 35.9	75.5 36.8	74.8 38.1	84
85	78.2 33.1	77.6 34.6	77.0 35.9	76.8 36.3	76.4 37.3	75.7 38.6	85
86	79.2 33.6	78.6 35.0	77.9 36.3	77.7 36.8	77.3 37.7	76.6 39.0	86
87	80.1 34.0	79.5 35.4	78.8 36.8	78.6 37.2	78.2 38.1	77.5 39.5	87
88	81.0 34.4	80.4 35.8	79.7 37.2	79.5 37.6	79.1 38.6	78.4 40.0	88
89	81.9 34.8	81.3 36.2	80.7 37.6	80.5 38.1	80.1 39.0	79.3 40.4	89
90	82.8 35.2	82.2 36.6	81.6 38.0	81.4 38.5	80.9 39.4	80.2 40.9	90
91	83.7 35.6	83.1 37.0	82.5 38.5	82.3 38.9	81.8 39.8	81.1 41.3	91
92	84.7 35.9	84.0 37.4	83.4 38.9	83.2 39.3	82.7 40.3	82.0 41.8	92
93	85.6 36.3	85.0 37.8	84.3 39.3	84.1 39.8	83.6 40.8	82.9 42.2	93
94	86.5 36.7	85.9 38.2	85.2 39.7	85.0 40.2	84.5 41.2	83.8 42.7	94
95	87.4 37.1	86.8 38.6	86.1 40.1	85.9 40.6	85.4 41.6	84.6 43.1	95
96	88.4 37.5	87.7 39.0	87.0 40.6	86.8 41.0	86.3 42.1	85.5 43.6	96
97	89.3 37.9	88.6 39.4	87.9 41.0	87.7 41.5	87.2 42.5	86.4 44.0	97
98	90.2 38.3	89.5 39.9	88.8 41.4	88.6 41.9	88.1 43.0	87.3 44.5	98
99	91.1 38.7	90.4 40.3	89.7 41.8	89.5 42.3	89.0 43.8	88.2 44.9	99
100	92.0 39.1	91.4 40.7	90.6 42.3	90.4 42.7	89.9 43.4	89.1 45.4	100
Diff.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Diff.
67 Deg.	66 Deg.	65 Deg.	54 Point	64 Deg.	63 Deg.		

D ^{ist}	28 Deg.	2 $\frac{1}{2}$ Point	29 Deg.	30 Deg.	2 $\frac{1}{2}$ Point	31 Deg.	D ^{ist}
	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	
1	00.9 00.5	00.9 00.5	00.9 00.5	00.9 00.5	00.9 00.5	00.9 00.5	1
2	01.8 00.9	01.8 00.9	01.0 01.0	01.7 01.0	01.7 01.0	01.7 01.0	2
3	02.6 01.4	02.6 01.4	02.6 01.4	02.6 01.5	02.6 01.5	02.6 01.5	3
4	03.5 01.9	03.5 01.9	03.5 01.9	03.5 02.0	03.4 02.1	03.4 02.1	4
5	04.4 02.3	04.4 02.4	04.4 02.4	04.3 02.5	04.3 02.6	04.3 02.6	5
6	05.3 02.8	05.3 02.8	05.2 02.9	05.2 03.0	05.1 03.1	05.1 03.1	6
7	06.2 03.3	06.2 03.3	06.1 03.4	06.1 03.5	06.0 03.6	06.0 03.6	7
8	07.1 03.8	07.1 03.8	07.0 03.9	06.9 04.0	06.9 04.1	06.9 04.1	8
9	07.9 04.2	07.9 04.2	07.9 04.4	07.8 04.5	07.7 04.6	07.7 04.6	9
10	08.8 04.7	08.8 04.7	08.7 04.8	08.7 05.0	08.6 05.1	08.6 05.1	10
11	09.7 05.2	09.7 05.2	09.6 05.3	09.5 05.5	09.4 05.6	09.4 05.7	11
12	10.6 05.6	10.6 05.6	10.5 05.8	10.4 06.0	10.3 06.2	10.3 06.2	12
13	11.5 06.1	11.5 06.1	11.4 06.3	11.3 06.5	11.1 06.7	11.1 06.7	13
14	12.4 06.6	12.3 06.6	12.2 06.8	12.1 07.0	12.0 07.2	12.0 07.2	14
15	13.2 07.0	13.2 07.1	13.1 07.3	13.0 07.5	12.9 07.7	12.9 07.7	15
16	14.1 07.5	14.1 07.5	14.0 07.7	13.9 08.0	13.7 08.2	13.7 08.2	16
17	15.0 08.0	15.0 08.0	14.9 08.2	14.7 08.5	14.6 08.7	14.6 08.8	17
18	15.9 08.4	15.9 08.5	15.7 08.7	15.6 09.0	15.4 09.2	15.4 09.3	18
19	16.8 08.9	16.8 08.9	16.6 09.2	16.4 09.5	16.3 09.8	16.3 09.8	19
20	17.7 09.4	17.6 09.4	17.5 09.7	17.3 10.0	17.1 10.3	17.1 10.3	20
21	18.5 09.9	18.5 09.9	18.4 10.2	18.2 10.5	18.0 10.8	18.0 10.8	21
22	19.4 10.3	19.4 10.3	19.2 10.7	19.0 11.0	18.9 11.3	18.9 11.3	22
23	20.3 10.8	20.3 10.8	20.1 11.1	19.9 11.5	19.7 11.8	19.7 11.8	23
24	21.2 11.3	21.2 11.3	21.0 11.6	20.8 12.0	20.6 12.3	20.6 12.4	24
25	22.1 11.7	22.0 11.8	21.9 12.1	21.6 12.5	21.4 12.8	21.4 12.9	25
26	23.0 12.2	22.9 12.3	22.7 12.6	22.5 13.0	22.3 13.4	22.3 13.4	26
27	23.8 12.7	23.8 12.7	23.6 13.1	23.4 13.5	23.1 13.9	23.1 13.9	27
28	24.7 13.1	24.7 13.2	24.5 13.6	24.2 14.0	24.0 14.4	24.0 14.4	28
29	25.6 13.6	25.6 13.7	25.4 14.1	25.1 14.5	24.9 14.9	24.9 14.9	29
30	26.5 14.1	26.5 14.1	26.2 14.5	26.0 15.0	25.7 15.4	25.7 15.4	30
31	27.4 14.5	27.3 14.6	27.1 15.0	26.8 15.5	26.6 15.9	26.6 16.0	31
32	28.2 15.0	28.2 15.1	28.0 15.5	27.7 16.0	27.4 16.4	27.4 16.5	32
33	29.1 15.5	29.1 15.5	28.9 16.0	28.6 16.5	28.3 17.0	28.3 17.0	33
34	30.0 16.0	30.0 16.0	29.7 16.5	29.5 17.0	29.2 17.5	29.1 17.5	34
35	30.9 16.4	30.9 16.5	30.6 17.0	30.3 17.5	30.0 18.0	30.0 18.0	35
36	31.8 16.9	31.7 17.0	31.5 17.4	31.2 18.0	30.9 18.5	30.9 18.5	36
37	32.7 17.4	32.6 17.4	32.4 17.9	32.0 18.5	31.7 19.0	31.7 19.1	37
38	33.5 17.9	33.5 17.9	33.2 18.4	32.9 19.0	32.5 19.5	32.6 19.6	38
39	34.4 18.3	34.4 18.4	34.1 18.9	33.8 19.5	33.4 20.0	33.4 20.1	39
40	35.3 18.8	35.3 18.9	35.0 19.4	34.6 20.0	34.3 20.5	34.3 20.6	40
41	36.2 19.2	36.1 19.3	35.8 19.9	35.5 20.5	35.2 21.1	35.1 21.1	41
42	37.1 19.7	37.0 19.8	36.7 20.4	36.4 21.0	36.0 21.6	36.0 21.6	42
43	38.0 20.1	37.9 20.3	37.6 20.8	37.2 21.5	36.9 22.1	36.9 22.1	43
44	38.8 20.6	38.8 20.7	38.5 21.3	38.1 22.0	37.7 22.6	37.7 22.6	44
45	39.7 21.1	39.7 21.2	39.3 21.8	39.0 22.5	38.6 23.1	38.6 23.2	45
46	40.6 21.6	40.6 21.7	40.2 22.3	39.8 23.0	39.5 23.6	39.4 23.7	46
47	41.5 22.1	41.4 22.2	41.1 22.8	40.7 23.5	40.3 24.2	40.3 24.2	47
48	42.4 22.5	42.3 22.6	42.0 23.3	41.6 24.0	41.2 24.7	41.1 24.7	48
49	43.3 23.1	43.2 23.2	42.8 23.7	42.4 24.5	42.0 25.2	42.0 25.2	49
50	44.1 23.5	44.1 23.6	43.7 24.2	43.3 25.0	42.9 25.7	42.9 25.7	50
D ^{ist}	Dep th	Dep th	Dep th	Dep th	Dep th	Dep th	D ^{ist}
	62 Deg.	5 $\frac{1}{2}$ Point	61 Deg.	60 Deg.	5 $\frac{1}{2}$ Point	59 Deg.	

	28 Deg.	2½ Point	29 Deg.	30 Deg.	2½ Point	31 Deg.	Diff.
	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
51	45.0 23.9	45.0 24.0	44.6 24.7	44.2 25.5	43.7 26.2	43.0 26.3	51
52	45.9 24.4	45.9 24.5	45.5 25.2	45.0 26.0	44.6 26.7	44.6 26.8	52
53	46.8 24.9	46.7 25.0	46.3 25.7	45.9 26.5	45.5 27.2	45.4 27.3	53
54	47.7 25.3	47.6 25.4	47.2 26.2	46.8 27.0	46.3 27.8	46.3 27.8	54
55	48.6 25.8	48.5 25.9	48.1 26.7	47.6 27.5	47.2 28.3	47.1 28.3	55
56	49.4 26.3	49.4 26.4	49.0 27.1	48.5 28.0	48.0 28.8	48.0 28.8	56
57	50.3 26.8	50.3 26.9	49.8 27.6	49.4 28.5	48.9 29.3	48.9 29.4	57
58	51.2 27.2	51.2 27.3	50.7 28.1	50.2 29.0	49.7 29.8	49.7 29.9	58
59	52.1 27.7	52.0 27.8	51.6 28.6	51.1 29.5	50.6 30.3	50.6 30.4	59
60	53.0 28.2	52.9 28.3	52.5 29.1	52.0 30.0	51.5 30.8	51.4 30.9	60
61	53.9 28.6	53.8 28.7	53.3 29.6	52.8 30.5	52.4 31.4	52.3 31.4	61
62	54.7 29.1	54.7 29.2	54.2 30.1	53.7 31.0	53.2 31.9	53.1 31.9	62
63	55.6 29.6	55.6 29.7	55.1 30.5	54.6 31.5	54.0 32.4	54.0 32.4	63
64	56.5 30.0	56.4 30.2	56.0 31.0	55.4 32.0	54.9 32.9	54.9 33.0	64
65	57.4 30.5	57.3 30.5	56.8 31.5	56.3 32.5	55.7 33.4	55.7 33.5	65
66	58.3 31.0	58.2 31.1	57.7 32.0	57.2 33.0	56.6 33.9	56.6 34.0	66
67	59.2 31.4	59.1 31.6	58.6 32.5	58.0 33.5	57.5 34.4	57.4 34.5	67
68	60.0 31.9	60.0 32.0	59.5 33.0	58.9 34.0	58.3 35.0	58.3 35.0	68
69	60.9 32.4	60.8 32.5	60.3 33.4	59.7 34.5	59.2 35.5	59.1 35.5	69
70	61.8 32.9	61.7 33.0	61.2 33.9	60.6 35.0	60.0 36.0	60.0 36.0	70
71	62.7 33.3	62.6 33.5	62.1 34.4	61.5 35.5	60.9 36.5	60.9 36.6	71
72	63.6 33.8	63.5 33.9	63.0 34.9	62.3 36.0	61.8 37.0	61.7 37.1	72
73	64.4 34.3	64.4 34.4	63.8 35.4	63.2 36.5	62.6 37.5	62.6 37.6	73
74	65.3 34.7	65.3 34.9	64.7 35.9	64.1 37.0	63.5 38.0	63.4 38.1	74
75	66.2 35.2	66.1 35.4	65.6 36.4	64.9 37.5	64.3 38.6	64.3 38.6	75
76	67.1 35.7	67.0 35.8	66.5 36.8	65.8 38.0	65.2 39.1	65.1 39.1	76
77	68.0 36.1	67.9 36.3	67.3 37.3	66.7 38.5	66.0 39.6	66.0 39.7	77
78	68.9 36.6	68.8 36.8	68.2 37.8	67.5 39.0	66.9 40.1	66.9 40.2	78
79	69.7 37.1	69.7 37.2	69.1 38.3	68.4 39.5	67.8 40.6	67.7 40.7	79
80	70.6 37.6	70.5 37.7	70.0 38.8	69.3 40.0	68.6 41.1	68.6 41.2	80
81	71.5 38.0	71.4 38.2	70.8 39.3	70.1 40.5	69.5 41.6	69.4 41.7	81
82	72.4 38.5	72.3 38.6	71.7 39.7	70.9 41.0	70.3 42.2	70.3 42.2	82
83	73.3 39.0	73.2 39.1	72.6 40.2	71.8 41.5	71.2 42.7	71.1 42.7	83
84	74.2 39.4	74.1 39.6	73.5 40.7	72.7 42.0	72.1 43.2	72.0 43.3	84
85	75.0 39.9	75.0 40.1	74.3 41.2	73.6 42.5	72.9 43.7	72.9 43.8	85
86	75.9 40.4	75.8 40.5	75.2 41.7	74.5 43.0	73.8 44.2	73.7 44.3	86
87	76.8 40.8	76.7 41.0	76.1 42.2	75.3 43.5	74.6 44.7	74.6 44.8	87
88	77.7 41.3	77.6 41.5	77.0 42.7	76.2 44.0	75.5 45.2	75.4 45.3	88
89	78.6 41.8	78.5 41.9	77.8 43.2	77.1 44.5	76.3 45.8	76.3 45.8	89
90	79.5 42.2	79.4 42.4	78.7 43.6	77.9 45.0	77.2 46.3	77.1 46.2	90
91	80.3 42.7	80.2 42.9	79.6 44.1	78.8 45.5	78.1 46.8	78.0 45.9	91
92	81.2 43.2	81.1 43.4	80.5 44.6	79.7 46.0	78.9 47.3	78.9 47.4	92
93	82.1 43.6	82.0 43.8	81.3 45.1	80.5 46.5	79.8 47.8	79.7 47.9	93
94	83.0 44.1	82.9 44.2	82.2 45.6	81.4 47.0	80.6 48.3	80.6 48.4	94
95	83.9 44.6	83.8 44.8	83.1 46.1	82.3 47.5	81.5 48.8	81.4 48.9	95
96	84.8 45.1	84.7 45.2	84.0 46.5	83.1 48.0	82.3 49.3	82.3 49.4	96
97	85.6 45.5	85.5 45.7	84.8 47.0	84.0 48.5	83.2 49.9	83.1 50.0	97
98	86.5 46.0	86.4 46.2	85.7 47.5	84.9 49.0	84.1 50.4	84.0 50.5	98
99	87.4 46.5	87.3 46.7	86.6 48.0	85.7 49.5	84.9 50.9	84.9 51.0	99
100	88.3 46.9	88.2 47.1	87.5 48.5	86.6 50.0	85.8 51.4	85.7 51.5	100
Diff.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Diff.
	62 Deg.	5½ Point	61 Deg.	60 Deg.	5½ Point	59 Deg.	

A Table of Difference

Diff	32 Deg.		33 Deg.		3 Points		34 Deg.		35 Deg.		36 Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	00.8	00.5	00.8	00.5	00.8	00.0	00.8	00.6	00.8	00.6	00.8	00.6
2	01.7	01.1	01.7	01.1	01.7	01.1	01.7	01.1	01.6	01.1	01.9	01.1
3	02.5	01.6	02.5	01.6	02.5	01.7	02.5	01.7	02.5	01.7	02.4	01.8
4	03.4	02.1	03.4	02.2	03.3	02.1	03.3	01.2	03.3	02.3	03.2	02.3
5	04.2	02.6	04.2	02.7	04.2	02.8	04.1	02.8	04.1	02.9	04.0	02.9
6	05.1	03.1	05.0	03.2	05.0	03.3	05.0	03.4	04.9	03.4	04.8	03.5
7	05.9	03.7	05.9	03.8	05.8	03.9	05.8	03.9	05.7	04.0	05.7	04.1
8	06.8	04.2	06.7	04.4	06.6	04.4	06.6	04.5	06.5	04.6	06.5	04.7
9	07.6	04.8	07.5	04.9	07.5	05.0	07.5	05.0	07.4	05.2	07.3	05.3
10	08.5	05.3	08.4	05.14	08.3	05.6	08.3	05.6	08.2	05.7	08.1	05.9
11	09.3	05.8	09.2	06.0	09.1	06.1	09.1	06.1	09.0	06.3	08.9	06.5
12	10.2	06.4	10.1	06.5	10.0	06.7	09.9	06.7	09.8	06.9	09.7	07.0
13	11.0	06.9	10.9	07.1	10.8	07.2	10.8	07.3	10.6	07.5	10.5	07.6
14	11.9	07.4	11.7	07.6	11.6	07.8	11.6	07.8	11.5	08.0	11.3	08.1
15	12.7	07.9	12.6	08.2	12.5	08.2	12.4	08.4	12.3	08.6	12.1	08.8
16	13.6	08.5	13.4	08.7	13.3	08.9	13.3	08.9	13.1	09.1	12.9	09.4
17	14.4	09.0	14.1	09.3	14.1	09.4	14.1	09.5	13.9	09.8	13.7	10.0
18	15.3	09.5	15.1	09.8	15.0	10.0	15.0	10.1	14.7	10.3	14.6	10.6
19	16.1	10.1	15.9	10.3	15.8	10.6	15.7	10.6	15.6	10.9	15.4	11.2
20	17.0	10.6	16.8	10.9	16.6	11.1	16.6	11.2	16.4	11.5	16.2	11.8
21	17.8	11.1	17.6	11.4	17.5	11.7	17.4	11.7	17.2	12.0	17.0	12.3
22	18.6	11.7	18.5	12.0	18.3	12.2	18.2	12.3	18.0	12.6	17.8	12.9
23	19.5	12.2	19.3	12.5	19.1	12.8	19.0	12.8	18.8	13.2	18.6	13.5
24	20.3	12.7	20.1	13.1	20.0	13.3	19.9	13.4	19.7	13.8	19.4	14.1
25	21.2	13.2	21.0	13.6	20.7	13.9	20.7	14.0	20.5	14.3	20.1	14.7
26	22.0	13.8	21.8	14.2	21.6	14.4	21.5	14.5	21.3	14.9	21.0	15.3
27	22.9	14.3	22.6	14.7	22.4	15.0	22.4	15.1	22.1	15.5	21.8	15.9
28	23.7	14.8	23.5	15.2	23.3	15.5	23.2	15.6	22.9	16.1	22.6	16.5
29	24.6	15.4	24.3	15.8	24.1	16.1	24.0	16.2	23.8	16.6	23.5	17.0
30	25.4	15.9	25.2	16.3	24.9	16.7	24.9	16.8	24.6	17.2	24.3	17.6
31	26.3	16.4	26.0	16.9	25.8	17.2	25.7	17.3	25.4	17.8	25.1	18.2
32	27.1	17.0	26.8	17.4	26.6	17.8	26.5	17.9	26.2	18.3	25.9	18.8
33	28.0	17.5	27.7	18.0	27.4	18.3	27.4	18.4	27.0	18.9	26.7	19.4
34	28.8	18.0	28.5	18.5	28.3	18.9	28.2	19.0	27.9	19.5	27.5	20.0
35	29.7	19.5	29.4	19.1	29.1	19.4	29.0	19.6	28.7	20.1	28.3	20.6
36	30.5	19.1	30.2	19.6	29.9	20.0	29.8	20.1	29.5	20.6	29.1	21.2
37	31.4	19.6	31.0	20.1	30.8	20.6	30.7	20.7	30.3	21.2	29.9	21.7
38	32.2	20.1	31.9	20.7	31.6	21.1	31.5	21.2	31.1	21.8	30.7	22.3
39	33.1	20.7	32.7	21.2	32.4	21.7	32.3	21.8	32.0	22.3	31.5	22.9
40	33.9	21.2	33.6	21.8	33.3	22.2	33.2	22.4	32.8	22.9	32.4	23.5
41	34.8	21.7	34.4	22.3	34.1	22.8	34.0	22.9	33.6	23.5	33.2	24.1
42	35.6	22.3	35.2	22.9	34.9	23.1	34.8	23.5	34.4	24.1	34.0	24.7
43	36.5	22.8	36.1	23.4	35.7	23.9	36.6	24.0	35.2	24.6	34.8	25.3
44	37.3	23.3	36.9	24.0	36.6	24.4	36.5	24.6	36.0	25.2	35.6	25.9
45	38.1	23.8	37.7	24.5	37.4	25.0	37.3	25.2	36.9	25.8	36.4	26.4
46	39.0	24.4	38.6	25.0	38.2	25.5	38.1	25.7	37.7	26.4	37.2	27.0
47	39.9	24.9	39.4	25.6	39.1	26.1	39.0	26.3	38.5	26.9	38.0	27.6
48	40.7	25.4	40.3	26.1	39.9	26.7	39.8	26.8	39.3	27.5	38.8	28.2
49	41.5	26.0	41.1	26.7	40.7	27.2	40.6	27.4	40.1	28.1	39.6	28.8
50	42.4	26.5	41.9	27.2	41.6	27.8	41.4	28.0	41.0	28.7	40.4	29.4
Diff	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.	Dep Lat.
	58 Deg.	57 Deg.	5 Points		56 Deg.	55 Deg.		54 Deg.				

32 Deg.	33 Deg.	3 Points	34 Deg.	35 Deg.	36 Deg.	Diff
Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	Lar. Dep	
43.2 27.0	43.8 27.8	42.4 28.3	42.3 28.5	41.8 29.2	41.3 30.0	51
44.1 27.6	43.6 28.2	43.2 28.9	43.1 29.1	42.6 29.8	42.1 30.6	52
44.9 28.1	44.5 28.9	44.1 29.4	43.9 29.6	43.4 30.4	42.9 31.2	53
45.8 28.6	45.3 29.4	44.9 30.0	44.5 30.2	44.2 31.0	43.7 31.7	54
46.6 29.1	46.1 30.0	45.7 30.6	45.6 30.7	45.1 31.5	44.5 32.3	55
47.5 29.7	47.0 30.5	46.6 31.1	46.4 31.3	45.9 32.1	45.2 32.9	56
48.3 30.2	47.8 31.0	47.4 31.7	47.3 31.9	46.7 32.7	46.1 33.5	57
49.2 30.7	48.7 31.6	48.2 32.2	48.1 32.4	47.5 33.3	46.9 34.1	58
50.0 31.3	49.5 32.1	48.0 32.8	48.9 33.0	48.3 33.8	47.7 34.7	59
50.9 31.8	50.3 32.7	49.9 33.3	49.7 33.5	49.1 34.4	48.5 35.3	60
51.7 32.3	51.2 33.2	50.7 33.9	50.6 34.1	50.0 34.9	49.3 35.9	61
52.6 32.9	52.0 33.8	51.5 34.4	51.4 34.7	50.8 35.6	50.2 36.4	62
53.4 33.4	52.9 34.3	52.4 35.0	52.2 35.2	51.6 36.1	51.0 37.0	63
54.3 33.9	53.7 34.9	53.2 35.5	53.1 35.8	52.4 36.7	51.8 37.6	64
55.1 34.4	54.5 35.4	54.0 36.1	53.9 36.3	53.2 37.3	52.6 38.2	65
56.0 35.0	55.3 35.9	54.9 36.7	54.7 36.9	54.1 37.9	53.4 38.8	66
56.8 35.5	56.2 36.5	55.7 37.2	55.5 37.5	54.9 38.4	54.2 39.4	67
57.7 36.0	57.0 37.0	56.5 37.8	56.4 38.0	55.7 39.0	55.0 40.0	68
58.5 36.6	57.9 37.6	57.4 38.3	57.2 38.6	56.5 39.6	55.8 40.6	69
59.4 37.1	58.7 38.1	58.2 38.9	58.0 39.1	57.3 40.1	56.6 41.1	70
60.2 37.6	59.6 38.7	59.0 39.4	58.9 39.7	58.2 40.7	57.4 41.7	71
61.0 38.1	60.4 39.2	59.8 40.0	59.7 40.3	59.0 41.3	58.2 42.3	72
61.9 38.7	61.2 39.8	60.7 40.6	60.5 40.8	59.8 41.9	59.1 42.9	73
62.7 39.2	62.1 40.3	61.5 41.1	61.3 41.4	60.6 42.4	59.9 43.5	74
63.6 39.7	62.9 40.8	62.4 41.7	62.2 41.9	61.4 43.0	60.0 44.1	75
64.4 40.3	63.8 41.5	63.2 42.2	63.0 42.5	62.3 43.6	61.5 44.7	76
65.3 40.8	64.6 41.9	64.0 42.8	63.8 43.0	63.1 44.2	62.3 45.3	77
66.1 41.3	65.4 42.5	64.8 43.3	64.7 43.6	63.9 44.7	63.1 45.8	78
67.0 41.9	66.3 43.0	65.7 43.9	65.5 44.2	64.7 45.3	63.9 46.4	79
67.8 42.4	67.1 43.6	66.5 44.4	66.3 44.7	65.5 45.9	64.7 47.0	80
68.7 42.9	68.0 44.1	67.3 45.0	67.1 45.3	66.4 46.5	65.5 47.6	81
69.5 43.4	68.8 44.7	68.2 45.5	68.0 45.8	67.2 47.0	66.3 48.2	82
70.4 44.0	69.6 45.2	69.0 46.1	68.8 46.4	68.0 47.6	67.1 48.8	83
71.2 44.5	70.5 45.8	69.8 46.7	69.6 47.0	68.8 48.2	68.0 49.4	84
72.1 45.0	71.3 46.3	70.7 47.2	70.5 47.5	69.6 48.8	68.8 50.0	85
72.9 45.6	72.1 46.8	71.5 47.8	71.3 48.1	70.5 49.3	69.6 50.5	86
73.8 46.1	73.0 47.3	72.3 48.3	72.1 48.6	71.3 49.9	70.4 51.1	87
74.6 46.6	73.8 47.9	73.2 48.9	72.9 49.2	72.1 50.5	71.2 51.7	88
75.5 47.2	74.7 48.5	74.0 49.4	73.8 49.8	72.9 51.0	72.0 52.3	89
76.3 47.7	75.5 49.0	74.8 50.0	74.6 50.3	73.7 51.6	72.8 52.9	90
77.2 48.2	76.3 49.6	75.7 50.6	75.4 50.9	74.5 52.2	73.6 53.5	91
78.0 48.7	77.2 50.1	76.5 51.1	76.3 51.4	75.4 52.8	74.4 54.1	92
78.9 49.3	77.2 50.6	77.3 51.7	77.1 52.0	76.2 53.3	75.2 54.7	93
79.7 49.8	78.0 51.2	78.2 52.2	77.9 52.6	77.0 53.9	76.0 55.2	94
80.6 50.3	79.7 51.7	79.0 52.8	78.8 53.1	77.8 54.5	76.9 55.8	95
81.4 50.9	80.5 52.3	79.8 53.3	79.6 53.7	78.6 55.1	77.7 56.4	96
82.3 51.4	81.4 52.8	80.6 53.9	80.4 54.2	79.5 55.6	78.5 57.0	97
83.1 51.9	82.2 53.4	81.5 54.4	81.3 54.8	80.3 56.2	79.3 57.6	98
84.0 52.5	83.1 53.9	82.3 55.0	82.1 55.4	81.1 56.8	80.1 58.2	99
84.8 53.0	83.9 54.5	83.1 55.6	82.9 55.9	81.9 57.4	80.9 58.8	100
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Diff
58 Deg.	57 Deg.	5 Points	56 Deg.	55 Deg.	54 Deg.	

D	34 Point	37 Deg.	38 Deg.	39 Deg.	41 Point	40 Deg.	D
Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep	Lat. Dep
1	00.8 00.6	00.8 00.6	00.8 00.6	00.8 00.7	00.8 00.6	00.8 00.6	1
2	01.6 01.2	01.6 01.2	01.6 01.2	01.5 01.3	01.5 01.3	01.5 01.3	2
3	02.4 01.8	02.4 01.8	02.4 01.8	02.3 01.9	02.3 01.9	02.3 01.9	3
4	03.2 02.4	03.2 02.4	03.1 02.1	03.1 02.5	03.1 02.5	03.1 02.5	4
5	04.0 03.0	04.0 03.0	04.0 03.0	03.9 03.1	03.9 03.2	03.8 03.2	5
6	04.8 03.6	04.8 03.6	04.7 03.7	04.6 03.9	04.6 03.8	04.6 03.9	6
7	05.6 04.2	05.6 04.2	05.5 04.3	05.4 04.4	05.4 04.4	05.4 04.5	7
8	06.4 04.8	06.4 04.8	06.3 04.9	06.2 05.0	06.2 05.1	06.1 05.1	8
9	07.2 05.4	07.2 05.4	07.1 05.5	07.0 05.7	07.0 05.7	06.9 05.8	9
10	08.0 06.0	08.0 06.0	07.9 06.2	07.8 06.3	07.7 06.3	07.7 06.4	10
11	08.8 06.6	08.8 06.6	08.7 06.8	08.5 06.9	08.5 07.0	08.4 07.1	11
12	09.6 07.1	09.6 07.2	09.4 07.4	09.3 07.5	09.3 07.6	09.2 07.7	12
13	10.4 07.7	10.4 07.8	10.2 08.0	10.1 08.2	10.0 08.2	10.0 08.4	13
14	11.2 08.3	11.2 08.4	11.0 08.6	10.9 08.8	10.8 08.9	10.7 09.0	14
15	12.0 08.9	12.0 09.0	11.8 09.2	11.6 09.4	11.6 09.5	11.5 09.6	15
16	12.8 09.5	12.8 09.6	12.6 09.8	12.4 10.1	12.4 10.1	12.3 10.3	16
17	13.6 10.1	13.6 10.2	13.4 10.5	13.2 10.7	13.1 10.8	13.0 10.9	17
18	14.4 10.7	14.4 10.8	14.2 11.1	13.9 11.3	13.9 11.4	13.8 11.6	18
19	15.3 11.3	15.2 11.4	15.0 11.7	14.8 12.0	14.7 12.0	14.5 12.2	19
20	16.1 11.9	16.0 12.0	15.8 12.3	15.5 12.6	15.5 12.7	15.3 12.9	20
21	16.9 12.5	16.8 12.6	16.5 12.9	16.3 13.2	16.2 13.3	16.1 13.5	21
22	17.7 13.1	17.6 13.2	17.3 13.5	17.1 13.8	17.0 14.0	16.8 14.1	22
23	18.5 13.7	18.4 13.8	18.1 14.2	17.9 14.5	17.8 14.6	17.6 14.8	23
24	19.3 14.3	19.2 14.4	18.9 14.8	18.6 15.1	18.5 15.2	18.4 15.4	24
25	20.1 14.9	20.0 15.0	19.7 15.4	19.4 15.7	19.3 15.9	19.1 16.1	25
26	20.9 15.5	20.8 15.6	20.5 16.0	20.2 16.4	20.1 16.5	19.9 16.7	26
27	21.7 16.1	21.6 16.2	21.3 16.6	21.0 17.0	20.9 17.1	20.7 17.4	27
28	22.5 16.7	22.4 16.8	22.1 17.2	21.8 17.6	21.6 17.8	21.4 18.0	28
29	23.3 17.3	23.2 17.4	22.8 17.8	22.1 18.3	22.4 18.4	22.2 18.6	29
30	24.1 17.9	24.0 18.0	23.6 18.5	23.3 18.9	23.2 19.0	23.0 19.3	30
31	24.9 18.5	24.8 18.6	24.4 19.1	24.1 19.5	24.0 19.7	23.7 19.9	31
32	25.7 19.1	25.6 19.3	25.2 19.7	24.9 20.1	24.7 20.3	24.5 20.6	32
33	26.5 19.7	26.4 19.9	26.0 20.3	25.6 20.8	25.5 20.9	25.3 21.1	33
34	27.3 20.3	27.1 20.5	26.8 20.9	26.4 21.4	26.3 21.6	26.0 21.9	34
35	28.1 20.8	27.9 21.1	27.6 21.5	27.2 22.0	27.0 22.2	26.8 22.5	35
36	28.9 21.4	28.7 21.7	28.4 22.2	27.7 22.7	27.8 22.8	27.6 23.1	36
37	29.7 22.0	29.5 22.3	29.2 22.8	28.8 23.3	28.6 23.5	28.3 23.8	37
38	30.5 22.6	30.3 22.9	29.9 23.4	29.5 23.9	29.4 24.1	29.1 24.4	38
39	31.3 23.2	31.1 23.5	30.7 24.0	30.3 24.5	30.1 24.7	29.9 25.1	39
40	32.1 23.8	31.9 24.1	31.5 24.6	31.1 25.2	30.9 25.4	30.6 25.7	40
41	32.9 24.4	32.7 24.7	32.3 25.2	31.9 25.8	31.7 26.0	31.4 26.4	41
42	33.7 25.0	33.5 25.3	33.1 25.9	32.6 26.4	32.5 26.6	32.2 27.0	42
43	34.5 25.6	34.3 25.9	33.9 26.5	33.4 27.1	33.2 27.3	32.9 27.6	43
44	35.3 26.2	35.1 26.5	34.7 27.1	34.2 27.7	34.0 27.9	33.7 28.3	44
45	36.1 26.8	35.9 27.1	35.5 27.7	35.0 28.3	34.8 28.5	34.5 28.9	45
46	36.9 27.4	36.7 27.7	36.2 28.3	35.7 29.0	35.6 29.2	35.2 29.6	46
47	37.7 28.0	37.5 28.3	37.0 28.9	36.5 29.6	36.3 29.8	36.0 30.2	47
48	38.5 28.6	38.3 28.9	37.8 29.5	37.8 30.2	37.1 30.4	36.8 30.9	48
49	39.3 29.2	39.1 29.5	38.6 30.2	38.1 30.8	37.9 31.1	37.5 31.5	49
50	40.2 29.8	39.9 30.1	39.4 30.8	38.9 31.5	38.6 31.7	38.3 32.1	50
D	Der. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	D
45 Point	52 Deg.	52 Deg.	51 Deg.	45 Point	50 Deg.		

Point	37 Deg.	38 Deg.	39 Deg.	40 Deg.	Point	41 Deg.
Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.
1	40.0 30.4	40.7 30.7	40.3 31.4	39.6 32.1	39.4 32.7	39.2 32.8
2	41.8 31.0	41.5 31.3	41.0 32.0	40.4 32.7	40.2 33.0	39.8 33.4
3	42.6 31.6	42.3 31.9	41.8 32.6	41.2 33.3	41.0 33.6	40.6 34.1
4	43.4 32.2	43.1 32.5	42.5 33.2	42.0 34.0	41.7 34.3	41.4 34.7
5	44.2 32.8	43.9 33.1	43.3 33.9	42.7 34.6	42.5 34.9	42.1 35.4
6	45.0 33.3	44.7 33.7	44.1 34.5	43.5 35.2	43.3 35.5	42.9 36.0
7	45.8 33.9	45.5 34.3	44.9 35.1	44.3 35.9	44.1 36.2	43.7 36.6
8	46.6 34.5	46.3 34.9	45.7 35.8	45.1 36.5	44.8 36.8	44.4 37.3
9	47.4 35.1	47.1 35.5	46.5 36.2	45.8 37.1	45.6 37.4	45.2 37.9
10	48.2 35.7	47.9 36.1	47.3 36.9	46.6 37.8	46.4 38.1	46.0 38.6
11	49.0 36.3	48.7 36.7	48.1 37.5	47.4 38.4	47.1 38.7	46.7 39.2
12	49.8 36.9	49.5 37.3	48.9 38.2	48.2 39.0	47.9 39.3	47.5 39.9
13	50.6 37.5	50.3 37.9	49.6 38.8	49.0 39.6	48.7 40.0	48.3 40.5
14	51.4 38.1	51.1 38.5	50.4 39.4	49.7 40.3	49.5 40.6	49.0 41.2
15	52.2 38.7	51.9 39.1	51.2 40.0	50.5 40.9	50.2 41.2	49.8 41.8
16	53.0 39.3	52.7 39.7	52.0 40.6	51.3 41.5	51.0 41.9	50.5 42.4
17	53.8 39.9	53.5 40.3	52.8 41.2	52.1 42.2	51.8 42.5	51.3 43.1
18	54.6 40.5	54.3 40.9	53.6 41.9	52.8 42.8	52.6 43.1	52.1 43.7
19	55.4 41.1	55.1 41.5	54.4 42.5	53.6 43.4	53.3 43.8	52.9 44.4
20	56.2 41.7	55.9 42.1	55.2 43.1	54.4 44.0	54.1 44.4	53.6 45.0
21	57.0 42.3	56.7 42.7	55.9 43.7	55.2 44.7	54.9 45.0	54.4 45.6
22	57.8 42.9	57.5 43.3	56.7 44.3	55.9 45.3	55.7 45.7	55.1 46.3
23	58.6 43.5	58.3 43.9	57.5 44.9	56.7 45.9	56.5 46.3	55.9 46.9
24	59.4 44.1	59.1 44.5	58.3 45.6	57.5 46.6	57.2 46.9	56.7 47.6
25	60.2 44.7	59.9 45.1	59.2 46.2	58.3 47.2	58.0 47.6	57.4 48.2
26	61.0 45.3	60.7 45.7	60.0 46.8	59.1 47.8	58.7 48.2	58.2 48.9
27	61.8 45.9	61.5 46.3	60.7 47.4	59.8 48.5	59.5 48.8	59.0 49.5
28	62.6 46.5	62.3 46.9	61.5 48.0	60.6 49.1	60.3 49.5	59.7 50.1
29	63.5 47.1	63.1 47.5	62.2 48.6	61.4 49.7	61.1 50.1	60.5 50.8
30	64.3 47.7	63.9 48.1	63.0 49.2	62.2 50.3	61.8 50.7	61.3 51.4
31	65.1 48.3	64.7 48.7	63.8 49.9	62.9 51.0	62.6 51.4	62.0 52.1
32	65.9 48.8	65.5 49.3	64.6 50.5	63.7 51.6	63.4 52.0	62.8 52.7
33	66.7 49.4	66.3 49.9	65.4 51.1	64.5 52.2	64.2 52.6	63.6 53.4
34	67.5 50.0	67.1 50.5	66.2 51.7	65.3 52.9	64.9 53.3	64.3 54.0
35	68.3 50.6	67.9 51.1	67.0 52.3	66.1 53.5	65.7 53.9	65.1 54.6
36	69.1 51.2	68.7 51.7	67.8 52.9	66.8 54.1	66.5 54.6	65.9 55.3
37	69.9 51.8	69.5 52.4	68.6 53.6	67.6 54.8	67.2 55.2	66.6 55.9
38	70.7 52.4	70.3 53.0	69.3 54.2	68.4 55.4	68.0 55.8	67.4 56.6
39	71.5 53.0	71.1 53.6	70.1 54.8	69.2 56.0	68.8 56.5	68.2 57.2
40	72.3 53.6	71.9 54.2	70.9 55.4	69.9 56.6	69.6 57.1	68.9 57.4
41	73.1 54.2	72.7 54.8	71.7 56.0	70.7 57.3	70.3 57.7	69.7 58.5
42	73.9 54.8	73.5 55.4	72.5 56.6	71.5 57.9	71.1 58.4	70.5 59.1
43	74.7 55.4	74.3 56.0	73.3 57.3	72.3 58.5	71.9 59.0	71.2 59.8
44	75.5 56.0	75.1 56.6	74.1 57.9	73.0 59.2	72.7 59.6	72.0 60.4
45	76.3 56.6	75.9 57.2	74.9 58.5	73.8 59.8	73.4 60.3	72.8 61.1
46	77.1 57.2	76.7 57.8	75.6 59.1	74.6 60.4	74.2 60.9	73.5 61.7
47	77.9 57.8	77.5 58.4	76.4 59.7	75.4 61.0	75.0 61.5	74.3 62.4
48	78.7 58.4	78.3 59.0	77.2 60.3	76.2 61.7	75.7 62.2	75.2 63.0
49	79.5 59.0	79.1 59.6	78.0 60.9	76.9 62.3	76.5 62.8	75.8 63.6
50	80.3 59.6	79.9 60.2	78.8 61.6	77.7 62.9	77.3 63.4	76.6 64.2
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.
1/2 Point	1/2 Deg.	1/2 Deg.	1/2 Deg.	1/2 Point	1/2 Deg.	1/2 Deg.

Dist.	41 Deg. Lat. Dep.	42 Deg. Lat. Dep.	3 $\frac{1}{2}$ Point Lat. Dep.	43 Deg. Lat. Dep.	44 Deg. Lat. Dep.	4 Points Lat. Dep.
1	00.7 00.7	00.7 00.7	00.7 00.7	00.7 00.7	00.7 00.7	00.7 00.7
2	01.5 01.3	01.5 01.3	01.5 01.3	01.5 01.4	01.5 01.4	01.5 01.4
3	02.3 02.0	02.2 02.0	02.2 02.0	02.2 02.0	02.2 02.1	02.1 02.1
4	03.0 02.6	03.0 02.7	03.0 02.7	02.9 01.7	02.9 02.8	02.8 02.8
5	03.8 03.3	03.7 03.3	03.7 03.4	03.6 03.4	03.6 03.5	03.5 03.5
6	04.5 03.9	04.5 04.0	04.4 04.0	04.4 04.1	04.3 04.2	04.1 04.2
7	05.3 04.6	05.1 04.7	05.1 04.7	05.1 04.8	05.0 04.9	04.9 04.9
8	06.0 05.2	05.9 05.3	05.9 05.4	05.8 05.5	05.7 05.6	05.7 05.7
9	06.8 05.9	06.7 06.0	06.7 06.0	06.6 06.1	06.5 06.2	06.4 06.4
10	07.5 06.6	07.4 06.7	07.4 06.7	07.3 06.8	07.2 06.9	07.1 07.1
11	08.3 07.2	08.2 07.4	08.1 07.4	08.0 07.5	07.9 07.6	07.8 07.8
12	09.1 07.9	08.9 08.0	08.9 08.1	08.8 08.2	08.6 08.3	08.5 08.5
13	09.8 08.5	09.7 08.7	09.6 08.7	09.5 08.9	09.3 09.0	09.2 09.2
14	10.6 09.1	10.4 09.4	10.4 09.4	10.1 09.5	10.1 09.7	09.9 09.9
15	11.3 09.8	11.1 10.0	11.1 10.1	11.0 10.2	10.8 10.4	10.6 10.6
16	12.1 10.5	11.9 10.7	11.9 10.7	11.7 10.9	11.5 11.1	11.3 12.3
17	12.8 11.1	12.6 11.4	12.6 11.4	12.4 12.6	12.3 11.8	12.0 12.0
18	13.6 11.8	13.4 12.0	13.3 12.1	13.2 12.3	12.9 12.5	12.7 12.7
19	14.3 12.5	14.1 12.7	14.1 12.8	13.9 13.0	13.7 13.2	13.4 13.4
20	15.1 13.1	14.9 13.4	14.8 13.4	14.6 13.6	14.4 13.9	14.1 14.1
21	15.8 13.8	15.6 14.0	15.6 14.1	15.4 14.3	15.1 14.6	14.8 14.8
22	16.6 14.4	16.3 14.7	16.3 14.8	16.1 15.0	15.8 15.3	15.5 15.5
23	17.4 15.1	17.1 15.4	17.0 15.4	16.8 15.7	16.5 16.0	16.3 16.3
24	18.1 15.7	17.8 16.1	17.8 16.1	17.5 16.4	17.2 16.7	17.0 17.0
25	18.9 16.4	18.6 16.7	18.5 16.8	18.3 17.1	18.0 17.4	17.7 17.7
26	19.6 17.1	19.3 17.5	19.3 17.4	19.0 17.7	18.7 18.1	18.4 18.4
27	20.4 17.7	20.1 18.1	20.0 18.1	19.7 18.4	19.4 18.8	19.1 19.1
28	21.1 18.4	20.8 18.7	20.7 18.8	20.5 19.1	20.1 19.4	19.8 19.8
29	21.9 19.0	21.5 19.4	21.5 19.5	21.2 19.8	20.9 20.1	20.5 20.5
30	22.6 19.7	22.2 20.1	22.2 20.1	21.9 20.5	21.6 20.8	21.3 21.3
31	23.4 20.3	23.0 20.7	23.0 20.8	22.6 21.1	22.3 21.5	21.9 21.9
32	24.1 21.0	23.8 21.4	23.7 21.5	23.4 21.8	23.0 22.2	22.6 22.6
33	24.9 21.6	24.5 22.1	24.4 22.2	24.1 22.5	23.7 22.9	23.3 23.3
34	25.6 22.3	25.3 22.7	25.2 22.8	24.9 23.2	24.5 23.6	24.0 24.0
35	26.4 23.0	26.0 23.4	25.9 23.5	25.6 23.9	25.2 24.3	24.7 24.7
36	27.2 23.6	26.7 24.1	26.7 24.2	26.3 24.5	25.9 25.0	25.4 25.4
37	27.9 24.3	27.5 24.7	27.4 24.8	27.0 25.2	26.6 25.7	26.1 26.1
38	28.7 24.9	28.2 25.4	28.2 25.5	27.8 25.9	27.3 26.4	26.9 26.9
39	29.4 25.6	29.0 26.1	28.6 25.2	28.5 26.6	28.0 27.1	27.6 27.6
40	30.2 26.2	29.7 26.8	29.9 26.9	29.2 27.3	28.8 27.8	28.3 28.3
41	31.0 26.9	30.5 27.4	30.4 27.5	30.0 28.0	29.5 28.5	29.0 29.0
42	31.7 27.5	31.2 28.1	31.1 28.2	30.7 28.6	30.2 29.2	29.7 29.7
43	32.5 28.2	31.9 28.8	31.9 28.9	31.4 29.3	30.9 29.9	30.4 30.4
44	33.2 28.9	32.7 29.4	32.6 29.5	32.2 30.0	31.6 30.6	31.1 31.1
45	34.0 29.2	32.4 30.1	33.3 30.2	32.9 30.7	32.4 31.3	31.8 31.8
46	34.7 30.2	34.2 30.8	34.1 30.9	33.6 31.4	33.1 32.0	32.5 32.5
47	35.5 30.8	34.9 31.4	34.8 31.6	34.4 32.1	33.8 32.6	33.2 33.2
48	36.3 31.5	35.7 32.1	35.6 32.2	35.1 32.7	34.5 33.3	33.9 33.9
49	37.0 32.1	36.4 32.8	36.3 32.9	35.8 33.4	35.2 34.0	34.6 34.6
50	37.7 32.8	37.2 33.5	37.0 33.6	36.6 34.1	36.0 34.7	35.3 35.3
Dist.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.
	49 Deg.	48 Deg.	4 $\frac{1}{2}$ Point	46 Deg.	46 Deg.	4 Points

41 Deg.	42 Deg.	3 $\frac{1}{2}$ Point	43 Deg.	44 Deg.	4 Points	Diff.
Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	Lat. Dep.	
38.5 33.5	37.9 34.1	37.8 34.2	37.3 34.8	36.7 35.4	36.1 36.1	51
39.4 34.1	38.6 34.8	38.5 34.9	38.0 35.5	37.4 36.1	36.8 36.8	52
40.0 34.8	39.4 35.5	39.3 35.6	38.8 36.1	38.1 36.8	37.5 37.5	53
40.8 35.4	40.1 36.1	40.0 36.3	39.5 36.8	38.8 37.5	38.2 38.2	54
41.5 36.0	40.9 36.8	40.7 36.9	40.2 37.5	39.6 38.2	38.9 38.9	55
42.3 36.7	41.6 37.5	41.5 37.6	41.0 38.2	40.3 38.9	39.6 39.6	56
43.0 37.4	42.4 38.1	42.2 38.3	41.7 38.9	41.0 39.6	40.3 40.3	57
43.8 38.1	43.1 38.8	43.0 38.9	42.4 39.5	41.7 40.3	41.0 41.0	58
44.5 38.7	43.8 39.5	43.7 39.6	43.1 40.2	42.4 41.0	41.7 41.7	59
45.3 39.4	44.6 40.1	44.5 40.3	43.8 40.9	43.2 41.7	42.4 42.4	60
46.0 40.0	45.3 40.8	45.2 41.0	44.6 41.7	43.9 42.4	43.1 43.1	61
46.8 40.7	46.1 41.5	45.9 41.6	45.3 42.3	44.6 43.1	43.8 43.8	62
47.6 41.3	46.8 42.2	46.7 42.3	46.1 43.0	45.3 43.8	44.5 44.5	63
48.3 42.0	47.5 42.8	47.4 43.0	46.8 43.6	46.0 44.5	45.3 45.3	64
49.1 42.6	48.3 43.5	48.2 43.6	47.5 44.3	46.8 45.1	46.0 46.0	65
49.8 43.3	49.0 44.2	48.9 44.3	48.3 45.0	47.5 45.8	46.7 46.7	66
50.6 44.0	49.8 44.8	49.6 45.0	49.0 45.7	48.2 46.5	47.4 47.4	67
51.3 44.6	50.5 45.5	50.4 45.7	49.7 46.4	48.9 47.2	48.1 48.1	68
52.1 45.3	51.3 46.2	51.1 46.3	50.5 47.1	49.6 47.9	48.8 48.8	69
52.8 45.9	52.0 46.8	51.9 47.0	51.2 47.7	50.3 48.6	49.5 49.5	70
53.6 46.6	52.8 47.5	52.6 47.7	51.9 48.4	51.1 49.3	50.2 50.2	71
54.3 47.2	53.5 48.2	53.3 48.3	52.7 49.1	51.8 50.0	50.9 50.9	72
55.1 47.9	54.2 48.8	54.1 49.0	53.4 49.8	52.5 50.7	51.6 51.6	73
55.9 48.5	55.0 49.5	54.8 49.7	54.1 50.5	53.2 51.4	52.3 52.3	74
56.6 49.2	55.7 50.2	55.6 50.4	54.8 51.1	53.9 52.1	53.0 53.0	75
57.4 49.9	56.5 50.9	56.3 51.0	55.6 51.8	54.7 52.8	53.7 53.7	76
58.1 50.5	57.2 51.5	57.1 51.7	56.3 52.5	55.4 53.5	54.4 54.4	77
58.9 51.2	58.0 52.1	57.8 52.4	57.0 53.2	56.1 54.2	55.2 55.2	78
59.6 51.8	58.7 52.8	58.5 53.0	57.8 53.9	56.8 54.9	55.9 55.9	79
60.4 52.5	59.4 53.5	59.3 53.7	58.5 54.6	57.5 55.6	56.6 56.6	80
61.1 53.1	60.2 54.2	60.0 54.4	59.2 55.2	58.3 56.3	57.3 57.3	81
61.9 53.8	60.9 54.9	60.8 55.1	60.0 55.9	59.0 57.0	58.0 58.0	82
62.6 54.5	61.7 55.5	61.5 55.7	60.7 56.6	59.7 57.6	58.7 58.7	83
63.4 55.1	62.4 56.2	62.2 56.4	61.4 57.3	60.4 58.3	59.4 59.4	84
64.2 55.9	63.2 56.9	63.0 57.1	62.2 58.0	61.1 59.0	60.1 60.1	85
64.9 56.4	63.9 57.5	63.7 57.7	63.0 58.6	61.9 59.7	60.8 60.8	86
65.7 57.1	64.7 58.2	64.5 58.4	63.6 59.3	62.6 60.4	61.5 61.5	87
66.4 57.7	65.4 58.9	65.2 59.2	64.4 60.0	63.3 61.1	62.2 62.2	88
67.2 58.4	66.1 59.6	65.9 59.8	65.1 60.7	64.0 61.8	62.9 62.9	89
67.9 59.0	66.9 60.2	66.7 60.4	65.8 61.4	64.7 62.5	63.6 63.6	90
68.7 59.7	67.6 60.9	67.4 61.1	66.5 62.1	65.5 63.2	64.3 64.3	91
69.4 60.4	68.4 61.6	68.2 61.8	67.3 62.7	66.2 63.9	65.0 65.0	92
70.2 61.0	69.1 62.2	68.9 62.4	68.0 63.4	66.9 64.6	65.8 65.8	93
71.0 61.7	69.9 62.9	69.6 63.1	68.7 64.1	67.6 65.3	66.5 66.5	94
71.7 62.3	70.6 63.6	70.4 63.8	69.5 64.8	68.4 66.0	67.2 67.2	95
72.5 63.0	71.3 64.2	71.1 64.5	70.2 65.5	69.1 66.7	67.9 67.9	96
73.2 63.6	72.1 64.9	71.9 65.1	70.9 66.1	69.8 67.4	68.6 68.6	97
74.0 64.3	72.8 65.6	72.6 65.8	71.7 66.8	70.5 68.1	69.3 69.3	98
74.7 65.0	73.6 66.2	73.4 66.5	72.4 67.5	71.2 68.8	70.0 70.0	99
75.5 65.6	74.3 66.9	74.1 67.2	73.1 68.2	71.9 69.5	70.7 70.7	100
Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Dep. Lat.	Diff.
49 Deg.	48 Deg.	4 $\frac{1}{2}$ Point	47 Deg.	46 Deg.	4 Point	

M. d.	10.	2.	3.	4.	5.	6.	7.	8.	9.	10.
0	0	60	120	180	240	300	361	421	481	541
1	1	61	121	181	241	301	362	422	482	542
2	2	62	122	182	242	302	363	423	483	543
3	3	63	123	183	243	303	364	424	484	544
4	4	64	124	184	244	304	365	425	485	545
5	5	65	125	185	245	305	366	426	486	546
6	6	66	126	186	246	306	367	427	487	547
7	7	67	127	187	247	307	368	428	488	548
8	8	68	128	188	248	308	369	429	489	549
9	9	69	129	189	249	309	370	430	491	551
10	10	70	130	190	250	310	371	431	492	552
11	11	71	131	191	251	311	372	432	493	553
12	12	72	132	192	252	312	373	433	494	554
13	13	73	133	193	253	313	374	434	495	555
14	14	74	134	194	254	314	375	435	496	556
15	15	75	135	195	255	315	376	436	497	557
16	16	76	136	196	256	316	377	437	498	558
17	17	77	137	197	257	317	378	438	499	559
18	18	78	138	198	258	318	379	439	500	560
19	19	79	139	199	259	319	380	440	501	561
20	20	80	140	200	260	320	381	441	502	562
21	21	81	141	201	261	321	382	442	503	563
22	22	82	142	202	262	322	383	443	504	564
23	23	83	143	203	263	323	384	444	505	565
24	24	84	144	204	264	324	385	445	506	566
25	25	85	145	205	265	325	386	446	507	567
26	26	86	146	206	266	326	387	447	508	568
27	27	87	147	207	267	327	388	448	509	569
28	28	88	148	208	268	328	389	449	510	570
29	29	89	149	209	269	329	390	450	511	571
30	30	90	150	210	270	330	391	451	512	572
31	31	91	151	211	271	331	392	452	513	573
32	32	92	152	212	272	332	393	453	514	574
33	33	93	153	213	273	333	394	454	515	575
34	34	94	154	214	274	334	395	455	516	576
35	35	95	155	215	275	335	396	456	517	577
36	36	96	156	216	276	336	397	457	518	578
37	37	97	157	217	277	337	398	458	519	579
38	38	98	158	218	278	338	399	459	520	580
39	39	99	159	219	279	339	400	460	521	581
40	40	100	160	220	280	340	401	461	522	582
41	41	101	161	221	281	341	402	462	523	583
42	42	102	162	222	282	342	403	463	524	584
43	43	103	163	223	283	343	404	464	525	585
44	44	104	164	224	284	344	405	465	526	586
45	45	105	165	225	285	345	406	466	527	587
46	46	106	166	226	286	346	407	467	528	588
47	47	107	167	227	287	347	408	468	529	589
48	48	108	168	228	288	348	409	469	530	590
49	49	109	169	229	289	349	410	470	531	591
50	50	110	170	230	290	350	411	471	532	592
51	51	111	171	231	291	351	412	472	533	593
52	52	112	172	232	292	352	413	473	534	594
53	53	113	173	233	293	353	414	474	535	595
54	54	114	174	234	294	354	415	475	536	596
55	55	115	175	235	295	355	416	476	537	597
56	56	116	176	236	296	356	417	477	538	598
57	57	117	177	237	297	357	418	478	539	599
58	58	118	178	238	298	358	419	479	540	600
59	59	119	179	239	299	359	420	480	541	601

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
664	725	787	848	910	973	1035	1098	1161	1224	1287	1350	1413	1476	1539	1602	1665	1728	1791	1854	1917	1980	2043	2106	2169	2232	2295	2358	2421	2484
665	726	788	849	911	974	1036	1099	1162	1225	1288	1351	1414	1477	1540	1603	1666	1729	1792	1855	1918	1981	2044	2107	2170	2233	2296	2359	2422	2485
666	727	789	850	912	975	1037	1100	1163	1226	1289	1352	1415	1478	1541	1604	1667	1730	1793	1856	1919	1982	2045	2108	2171	2234	2297	2360	2423	2486
667	728	790	851	913	976	1038	1101	1164	1227	1290	1353	1416	1479	1542	1605	1668	1731	1794	1857	1920	1983	2046	2109	2172	2235	2298	2361	2424	2487
668	729	791	852	914	977	1039	1102	1165	1228	1291	1354	1417	1480	1543	1606	1669	1732	1795	1858	1921	1984	2047	2110	2173	2236	2299	2362	2425	2488
669	730	792	853	915	978	1040	1103	1166	1229	1292	1355	1418	1481	1544	1607	1670	1733	1796	1859	1922	1985	2048	2111	2174	2237	2300	2363	2426	2489
670	731	793	854	916	979	1041	1104	1167	1230	1293	1356	1419	1482	1545	1608	1671	1734	1797	1860	1923	1986	2049	2112	2175	2238	2301	2364	2427	2490
671	732	794	855	917	980	1042	1105	1168	1231	1294	1357	1420	1483	1546	1609	1672	1735	1798	1861	1924	1987	2050	2113	2176	2239	2302	2365	2428	2491
672	733	795	856	918	981	1043	1106	1169	1232	1295	1358	1421	1484	1547	1610	1673	1736	1799	1862	1925	1988	2051	2114	2177	2240	2303	2366	2429	2492
673	734	796	857	919	982	1044	1107	1170	1233	1296	1359	1422	1485	1548	1611	1674	1737	1800	1863	1926	1989	2052	2115	2178	2241	2304	2367	2430	2493
674	735	797	858	920	983	1045	1108	1171	1234	1297	1360	1423	1486	1549	1612	1675	1738	1801	1864	1927	1990	2053	2116	2179	2242	2305	2368	2431	2494
675	736	798	859	921	984	1046	1109	1172	1235	1298	1361	1424	1487	1550	1613	1676	1739	1802	1865	1928	1991	2054	2117	2180	2243	2306	2369	2432	2495
676	737	799	860	922	985	1047	1110	1173	1236	1299	1362	1425	1488	1551	1614	1677	1740	1803	1866	1929	1992	2055	2118	2181	2244	2307	2370	2433	2496
677	738	800	861	923	986	1048	1111	1174	1237	1300	1363	1426	1489	1552	1615	1678	1741	1804	1867	1930	1993	2056	2119	2182	2245	2308	2371	2434	2497
678	739	801	862	924	987	1049	1112	1175	1238	1301	1364	1427	1490	1553	1616	1679	1742	1805	1868	1931	1994	2057	2120	2183	2246	2309	2372	2435	2498
679	740	802	863	925	988	1050	1113	1176	1239	1302	1365	1428	1491	1554	1617	1680	1743	1806	1869	1932	1995	2058	2121	2184	2247	2310	2373	2436	2499
680	741	803	864	926	989	1051	1114	1177	1240	1303	1366	1429	1492	1555	1618	1681	1744	1807	1870	1933	1996	2059	2122	2185	2248	2311	2374	2437	2500
681	742	804	865	927	990	1052	1115	1178	1241	1304	1367	1430	1493	1556	1619	1682	1745	1808	1871	1934	1997	2060	2123	2186	2249	2312	2375	2438	2501
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57	26	11	98	87	78	70	64	60	58	58	60	60	60	60	60	60	60
58	27	13	3200	89	79	71	66	62	61	61	63	63	63	63	63	63	63
59	29	14	01	90	81	72	67	64	62	62	64	64	64	64	64	64	64

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
3968	4074	4181	4288	4395	4502	4609	4716	4823	4930	5037	5144	5251	5358	5465	5572	5679	5786	5893	5900	6007	6114	6221	6328	6435	6542	6649	6756	6863	6970	7077	7184	7291	7398	7505	7612	7719	7826	7933	8040	8147	8254	8361	8468	8575	8682	8789	8896	9003	9110	9217	9324	9431	9538	9645	9752	9859	9966	0073	0180	0287	0394	0501	0608	0715	0822	0929	1036	1143	1250	1357	1464	1571	1678	1785	1892	1999	2106	2213	2320	2427	2534	2641	2748	2855	2962	3069	3176	3283	3390	3497	3604	3711	3818	3925	4032	4139	4246	4353	4460	4567	4674	4781	4888	4995	5102	5209	5316	5423	5530	5637	5744	5851	5958	6065	6172	6279	6386	6493	6600	6707	6814	6921	7028	7135	7242	7349	7456	7563	7670	7777	7884	7991	8098	8205	8312	8419	8526	8633	8740	8847	8954	9061	9168	9275	9382	9489	9596	9703	9810	9917	0024	0131	0238	0345	0452	0559	0666	0773	0880	0987	1094	1201	1308	1415	1522	1629	1736	1843	1950	2057	2164	2271	2378	2485	2592	2699	2806	2913	3020	3127	3234	3341	3448	3555	3662	3769	3876	3983	4090	4197	4304	4411	4518	4625	4732	4839	4946	5053	5160	5267	5374	5481	5588	5695	5802	5909	6016	6123	6230	6337	6444	6551	6658	6765	6872	6979	7086	7193	7300	7407	7514	7621	7728	7835	7942	8049	8156	8263	8370	8477	8584	8691	8798	8905	9012	9119	9226	9333	9440	9547	9654	9761	9868	9975	0082	0189	0296	0403	0510	0617	0724	0831	0938	1045	1152	1259	1366	1473	1580	1687	1794	1901	2008	2115	2222	2329	2436	2543	2650	2757	2864	2971	3078	3185	3292	3399	3506	3613	3720	3827	3934	4041	4148	4255	4362	4469	4576	4683	4790	4897	4904	5011	5118	5225	5332	5439	5546	5653	5760	5867	5974	6081	6188	6295	6402	6509	6616	6723	6830	6937	7044	7151	7258	7365	7472	7579	7686	7793	7900	8007	8114	8221	8328	8435	8542	8649	8756	8863	8970	9077	9184	9291	9398	9505	9612	9719	9826	9933	0040	0147	0254	0361	0468	0575	0682	0789	0896	1003	1110	1217	1324	1431	1538	1645	1752	1859	1966	2073	2180	2287	2394	2501	2608	2715	2822	2929	3036	3143	3250	3357	3464	3571	3678	3785	3892	4000	4107	4214	4321	4428	4535	4642	4749	4856	4963	5070	5177	5284	5391	5498	5605	5712	5819	5926	6033	6140	6247	6354	6461	6568	6675	6782	6889	6996	7103	7210	7317	7424	7531	7638	7745	7852	7959	8066	8173	8280	8387	8494	8601	8708	8815	8922	9029	9136	9243	9350	9457	9564	9671	9778	9885	9992	0099	0206	0313	0420	0527	0634	0741	0848	0955	1062	1169	1276	1383	1490	1597	1704	1811	1918	2025	2132	2239	2346	2453	2560	2667	2774	2881	2988	3095	3202	3309	3416	3523	3630	3737	3844	3951	4058	4165	4272	4379	4486	4593	4700	4807	4914	5021	5128	5235	5342	5449	5556	5663	5770	5877	5984	6091	6198	6305	6412	6519	6626	6733	6840	6947	7054	7161	7268	7375	7482	7589	7696	7803	7910	8017	8124	8231	8338	8445	8552	8659	8766	8873	8980	9087	9194	9301	9408	9515	9622	9729	9836	9943	0050	0157	0264	0371	0478	0585	0692	0799	0906	1013	1120	1227	1334	1441	1548	1655	1762	1869	1976	2083	2190	2297	2404	2511	2618	2725	2832	2939	3046	3153	3260	3367	3474	3581	3688	3795	3902	4009	4116	4223	4330	4437	4544	4651	4758	4865	4972	5079	5186	5293	5400	5507	5614	5721	5828	5935	6042	6149	6256	6363	6470	6577	6684	6791	6898	7005	7112	7219	7326	7433	7540	7647	7754	7861	7968	8075	8182	8289	8396	8503	8610	8717	8824	8931	9038	9145	9252	9359	9466	9573	9680	9787	9894	9999

M	66 d	67 d	68 d	69 d	70 d	71 d	72 d	73 d	74 d	75 d	76 d	M
0	5324	5474	5631	5795	5967	6146	6335	6535	6747	6971	7211	0
1	26	77	34	98	70	50	39	39	50	75	15	1
2	29	80	37	5801	72	53	42	42	54	79	20	2
3	31	82	39	04	75	56	45	46	58	83	24	3
4	34	85	42	06	78	59	49	49	61	87	28	4
5	36	87	45	09	81	62	52	52	65	91	32	5
6	39	90	47	12	84	65	55	56	69	95	36	6
7	41	92	50	15	87	68	58	59	72	99	40	7
8	44	95	53	18	90	71	62	63	76	45	45	8
9	46	98	55	20	93	74	65	66	78	49	49	9
10	5349	5505	5658	5823	5996	6177	6368	6570	6783	7010	7253	10
11	51	03	61	26	99	80	71	73	87	14	57	11
12	54	05	64	29	6002	83	75	77	91	18	61	12
13	56	08	66	32	05	87	78	80	94	22	65	13
14	59	11	69	34	08	90	81	84	98	26	70	14
15	61	13	72	37	11	93	85	87	6802	30	74	15
16	64	16	74	40	14	96	88	90	05	34	78	16
17	66	18	77	43	17	99	91	94	09	38	82	17
18	68	21	80	46	20	6202	94	97	13	42	87	18
19	71	23	82	49	23	05	98	6601	16	46	91	19
20	5373	5526	5685	5851	6026	6208	6401	6605	6820	7050	7295	20
21	76	29	88	54	29	12	04	08	24	54	99	21
22	78	31	91	57	32	15	08	11	27	58	7303	22
23	81	34	93	60	34	18	11	15	31	61	08	23
24	83	37	96	63	38	21	14	18	35	65	12	24
25	86	39	99	66	40	24	18	22	39	69	16	25
26	88	42	5701	68	43	27	21	25	42	73	21	26
27	91	44	04	71	46	30	24	29	45	77	25	27
28	93	47	07	74	49	34	27	32	50	81	29	28
29	96	49	10	77	52	37	31	36	54	85	33	29
30	5398	5552	5712	5880	6055	6240	6434	6639	6857	7089	7338	30
31	5401	55	15	83	58	43	37	43	61	93	42	31
32	03	57	18	86	61	46	41	47	65	97	46	32
33	06	60	21	88	64	49	44	51	69	7101	60	33
34	09	63	23	91	67	52	47	54	72	05	55	34
35	11	65	26	94	70	56	51	57	76	09	59	35
36	14	68	29	97	73	59	54	61	80	13	63	36
37	16	70	32	5900	76	62	57	64	84	17	68	37
38	19	73	34	03	79	65	61	68	87	21	72	38
39	21	76	37	06	82	68	64	71	91	26	76	39
40	5424	5578	5740	5909	6085	6271	6468	6675	6895	7130	7381	40
41	26	81	42	11	89	75	71	78	99	34	85	41
42	29	84	45	14	92	78	74	82	6903	38	89	42
43	31	86	48	17	95	81	78	86	06	42	94	43
44	34	89	51	20	98	84	81	89	10	46	98	44
45	36	92	54	23	6101	87	84	92	14	50	7403	45
46	39	94	56	26	04	91	88	96	18	54	07	46
47	41	97	59	29	07	94	91	6700	22	58	11	47
48	44	99	62	32	10	97	94	03	25	62	16	48
49	45	5601	65	35	12	6300	98	07	29	66	20	49
50	5449	5605	5767	5937	6116	6303	6501	6711	6933	7170	7424	50
51	52	07	70	40	10	07	05	14	37	74	29	51
52	54	10	73	43	22	10	08	18	41	78	33	52
53	58	13	76	46	25	13	11	21	44	82	38	53
54	59	15	78	49	28	16	15	25	48	87	42	54
55	62	18	81	52	31	19	18	19	52	91	46	55
56	64	21	84	55	34	23	22	32	56	95	51	56
57	67	23	87	58	37	25	25	35	60	99	55	57
58	69	26	90	61	40	29	28	39	64	7103	59	58
59	72	29	92	64	43	32	32	43	68	07	54	59

	77 d	78 d	79 d	80 d	81 d	82 d	83 d	84 d	85 d	M
0	7469	7746	8047	8377	8741	9148	9609	10148	10770	0
1	73	51	53	83	48	55	17	150	781	1
2	78	56	58	89	54	63	10	160	793	2
3	82	61	63	95	61	70	34	170	804	3
4	86	65	69	8400	67	77	42	179	816	4
5	91	70	74	06	74	84	50	189	827	5
6	95	75	79	12	80	92	59	199	839	6
7	7500	80	84	18	87	99	67	209	851	7
8	04	85	90	24	93	9206	75	218	863	8
9	09	90	95	30	99	14	84	228	875	9
10	7513	7795	8100	8435	8806	9221	9692	10238	10886	10
11	18	99	06	41	13	18	9701	248	899	11
12	22	7804	11	47	19	36	09	258	910	12
13	27	09	16	53	26	43	18	268	922	13
14	31	14	22	59	32	50	26	278	934	14
15	36	19	27	65	39	58	35	288	946	15
16	40	24	32	71	45	65	43	298	958	16
17	45	29	38	77	52	73	52	308	971	17
18	50	34	43	83	59	80	60	318	983	18
19	54	39	49	89	65	88	69	328	995	19
20	7559	7844	8154	8494	8872	9295	9777	10338	11007	20
21	63	49	59	8500	78	93	86	348	020	21
22	68	54	65	06	85	10	95	358	032	22
23	72	59	70	12	92	18	9803	368	047	23
24	77	64	76	18	98	25	12	378	058	24
25	82	69	81	24	8905	33	21	389	070	25
26	86	75	87	30	12	40	30	399	082	26
27	91	79	92	36	19	48	38	410	095	27
28	95	84	98	42	25	56	47	420	107	28
29	7600	89	8203	49	32	63	56	430	120	29
30	7605	7894	8208	8555	8939	9371	9865	10441	11133	30
31	09	99	14	61	46	79	74	451	146	31
32	14	7904	19	67	52	86	82	462	158	32
33	19	09	25	73	59	94	91	472	171	33
34	23	14	31	79	66	9402	9900	483	184	34
35	28	19	36	85	73	10	09	494	197	35
36	32	24	42	91	80	17	18	504	210	36
37	37	29	47	97	87	25	27	515	223	37
38	42	34	53	8603	95	33	36	526	236	38
39	46	39	58	10	9000	41	45	536	258	39
40	7651	7944	8264	8616	9007	9449	9954	10547	11163	40
41	56	49	69	12	14	56	63	558	276	41
42	61	54	75	28	31	64	73	569	289	42
43	65	59	80	34	28	72	82	579	303	43
44	70	65	86	41	35	80	92	590	316	44
45	75	70	92	47	42	88	10000	601	330	45
46	79	75	97	53	49	96	009	612	343	46
47	84	80	8303	59	56	9504	018	623	357	47
48	89	85	09	65	62	12	028	634	371	48
49	94	90	15	72	70	20	037	645	384	49
50	7698	7995	8320	8678	9077	9528	10046	10656	11398	50
51	7703	8001	26	84	84	36	056	668	412	51
52	08	05	31	91	91	44	065	679	416	52
53	13	11	37	97	98	52	074	690	440	53
54	17	16	43	8703	9105	60	084	701	454	54
55	22	21	49	10	12	68	093	713	468	55
56	27	27	54	16	20	76	103	724	48	56
57	32	32	60	22	27	85	112	735	496	57
58	37	37	66	29	34	93	122	747	510	58
59	41	43	71	35	41	9401	131	758	525	59

M	86 d	87 d	88 d	89 d	M
0	31539	12511	13910	16317	0
1	553	540	949	376	1
2	568	519	978	435	2
3	582	579	14007	495	3
4	597	598	037	557	4
5	611	618	067	619	5
6	626	638	097	682	6
7	641	658	127	748	7
8	656	678	158	814	8
9	671	698	189	881	9
10	11686	12718	14220	16950	10
11	701	738	252	020	11
12	716	759	284	092	12
13	731	779	316	165	13
14	746	800	348	240	14
15	761	821	381	310	15
16	777	842	414	394	16
17	792	863	448	474	17
18	808	884	481	556	18
19	823	906	515	640	19
20	11839	12027	14550	17726	20
21	855	949	584	814	21
22	870	970	619	904	22
23	886	992	655	997	23
24	901	13014	691	18093	24
25	918	037	727	191	25
26	934	059	764	292	26
27	950	081	800	396	27
28	967	104	838	503	28
29	983	127	876	615	29
30	11999	13150	14914	18729	30
31	12016	172	952	848	31
32	082	196	992	971	32
33	049	219	15031	19098	33
34	066	243	071	230	34
35	086	267	111	368	35
36	099	294	152	511	36
37	116	315	194	660	37
38	133	339	236	817	38
39	150	363	278	980	39
40	12167	13388	15321	20152	40
41	185	413	365	333	41
42	202	437	409	524	42
43	220	463	453	726	43
44	237	488	499	941	44
45	255	513	545	21170	45
46	273	539	591	416	46
47	290	565	638	680	47
48	308	591	686	967	48
49	326	617	734	22279	49
50	12344	13643	15182	23623	50
51	363	670	823	23005	51
52	381	697	884	23435	52
53	398	724	935	23926	53
54	408	751	987	24499	54
55	426	775	16040	25786	55
56	445	807	094	26038	56
57	464	834	148	27192	57
58	483	865	205	28911	58
59	50	891	260	32348	59

A Table of the Sun's Declination

From the Equinox to the Solstices
1711 1712

Month	Day	Declination	Hour	Minute	Second
Jan.	1	23° 27'	0	0	0
Jan.	2	23° 26'	0	0	0
Jan.	3	23° 25'	0	0	0
Jan.	4	23° 24'	0	0	0
Jan.	5	23° 23'	0	0	0
Jan.	6	23° 22'	0	0	0
Jan.	7	23° 21'	0	0	0
Jan.	8	23° 20'	0	0	0
Jan.	9	23° 19'	0	0	0
Jan.	10	23° 18'	0	0	0
Jan.	11	23° 17'	0	0	0
Jan.	12	23° 16'	0	0	0
Jan.	13	23° 15'	0	0	0
Jan.	14	23° 14'	0	0	0
Jan.	15	23° 13'	0	0	0
Jan.	16	23° 12'	0	0	0
Jan.	17	23° 11'	0	0	0
Jan.	18	23° 10'	0	0	0
Jan.	19	23° 9'	0	0	0
Jan.	20	23° 8'	0	0	0
Jan.	21	23° 7'	0	0	0
Jan.	22	23° 6'	0	0	0
Jan.	23	23° 5'	0	0	0
Jan.	24	23° 4'	0	0	0
Jan.	25	23° 3'	0	0	0
Jan.	26	23° 2'	0	0	0
Jan.	27	23° 1'	0	0	0
Jan.	28	22° 59'	0	0	0
Jan.	29	22° 58'	0	0	0
Jan.	30	22° 57'	0	0	0
Feb.	1	22° 56'	0	0	0
Feb.	2	22° 55'	0	0	0
Feb.	3	22° 54'	0	0	0
Feb.	4	22° 53'	0	0	0
Feb.	5	22° 52'	0	0	0
Feb.	6	22° 51'	0	0	0
Feb.	7	22° 50'	0	0	0
Feb.	8	22° 49'	0	0	0
Feb.	9	22° 48'	0	0	0
Feb.	10	22° 47'	0	0	0
Feb.	11	22° 46'	0	0	0
Feb.	12	22° 45'	0	0	0
Feb.	13	22° 44'	0	0	0
Feb.	14	22° 43'	0	0	0
Feb.	15	22° 42'	0	0	0
Feb.	16	22° 41'	0	0	0
Feb.	17	22° 40'	0	0	0
Feb.	18	22° 39'	0	0	0
Feb.	19	22° 38'	0	0	0
Feb.	20	22° 37'	0	0	0
Feb.	21	22° 36'	0	0	0
Feb.	22	22° 35'	0	0	0
Feb.	23	22° 34'	0	0	0
Feb.	24	22° 33'	0	0	0
Feb.	25	22° 32'	0	0	0
Feb.	26	22° 31'	0	0	0
Feb.	27	22° 30'	0	0	0
Feb.	28	22° 29'	0	0	0
Feb.	29	22° 28'	0	0	0
Feb.	30	22° 27'	0	0	0
Mar.	1	22° 26'	0	0	0
Mar.	2	22° 25'	0	0	0
Mar.	3	22° 24'	0	0	0
Mar.	4	22° 23'	0	0	0
Mar.	5	22° 22'	0	0	0
Mar.	6	22° 21'	0	0	0
Mar.	7	22° 20'	0	0	0
Mar.	8	22° 19'	0	0	0
Mar.	9	22° 18'	0	0	0
Mar.	10	22° 17'	0	0	0
Mar.	11	22° 16'	0	0	0
Mar.	12	22° 15'	0	0	0
Mar.	13	22° 14'	0	0	0
Mar.	14	22° 13'	0	0	0
Mar.	15	22° 12'	0	0	0
Mar.	16	22° 11'	0	0	0
Mar.	17	22° 10'	0	0	0
Mar.	18	22° 9'	0	0	0
Mar.	19	22° 8'	0	0	0
Mar.	20	22° 7'	0	0	0
Mar.	21	22° 6'	0	0	0
Mar.	22	22° 5'	0	0	0
Mar.	23	22° 4'	0	0	0
Mar.	24	22° 3'	0	0	0
Mar.	25	22° 2'	0	0	0
Mar.	26	22° 1'	0	0	0
Mar.	27	21° 59'	0	0	0
Mar.	28	21° 58'	0	0	0
Mar.	29	21° 57'	0	0	0
Mar.	30	21° 56'	0	0	0
Apr.	1	21° 55'	0	0	0
Apr.	2	21° 54'	0	0	0
Apr.	3	21° 53'	0	0	0
Apr.	4	21° 52'	0	0	0
Apr.	5	21° 51'	0	0	0
Apr.	6	21° 50'	0	0	0
Apr.	7	21° 49'	0	0	0
Apr.	8	21° 48'	0	0	0
Apr.	9	21° 47'	0	0	0
Apr.	10	21° 46'	0	0	0
Apr.	11	21° 45'	0	0	0
Apr.	12	21° 44'	0	0	0
Apr.	13	21° 43'	0	0	0
Apr.	14	21° 42'	0	0	0
Apr.	15	21° 41'	0	0	0
Apr.	16	21° 40'	0	0	0
Apr.	17	21° 39'	0	0	0
Apr.	18	21° 38'	0	0	0
Apr.	19	21° 37'	0	0	0
Apr.	20	21° 36'	0	0	0
Apr.	21	21° 35'	0	0	0
Apr.	22	21° 34'	0	0	0
Apr.	23	21° 33'	0	0	0
Apr.	24	21° 32'	0	0	0
Apr.	25	21° 31'	0	0	0
Apr.	26	21° 30'	0	0	0
Apr.	27	21° 29'	0	0	0
Apr.	28	21° 28'	0	0	0
Apr.	29	21° 27'	0	0	0
Apr.	30	21° 26'	0	0	0
May	1	21° 25'	0	0	0
May	2	21° 24'	0	0	0
May	3	21° 23'	0	0	0
May	4	21° 22'	0	0	0
May	5	21° 21'	0	0	0
May	6	21° 20'	0	0	0
May	7	21° 19'	0	0	0
May	8	21° 18'	0	0	0
May	9	21° 17'	0	0	0
May	10	21° 16'	0	0	0
May	11	21° 15'	0	0	0
May	12	21° 14'	0	0	0
May	13	21° 13'	0	0	0
May	14	21° 12'	0	0	0
May	15	21° 11'	0	0	0
May	16	21° 10'	0	0	0
May	17	21° 9'	0	0	0
May	18	21° 8'	0	0	0
May	19	21° 7'	0	0	0
May	20	21° 6'	0	0	0
May	21	21° 5'	0	0	0
May	22	21° 4'	0	0	0
May	23	21° 3'	0	0	0
May	24	21° 2'	0	0	0
May	25	21° 1'	0	0	0
May	26	20° 59'	0	0	0
May	27	20° 58'	0	0	0
May	28	20° 57'	0	0	0
May	29	20° 56'	0	0	0
May	30	20° 55'	0	0	0
Jun.	1	20° 54'	0	0	0
Jun.	2	20° 53'	0	0	0
Jun.	3	20° 52'	0	0	0
Jun.	4	20° 51'	0	0	0
Jun.	5	20° 50'	0	0	0
Jun.	6	20° 49'	0	0	0
Jun.	7	20° 48'	0	0	0
Jun.	8	20° 47'	0	0	0
Jun.	9	20° 46'	0	0	0
Jun.	10	20° 45'	0	0	0
Jun.	11	20° 44'	0	0	0
Jun.	12	20° 43'	0	0	0
Jun.	13	20° 42'	0	0	0
Jun.	14	20° 41'	0	0	0
Jun.	15	20° 40'	0	0	0
Jun.	16	20° 39'	0	0	0
Jun.	17	20° 38'	0	0	0
Jun.	18	20° 37'	0	0	0
Jun.	19	20° 36'	0	0	0
Jun.	20	20° 35'	0	0	0
Jun.	21	20° 34'	0	0	0
Jun.	22	20° 33'	0	0	0
Jun.	23	20° 32'	0	0	0
Jun.	24	20° 31'	0	0	0
Jun.	25	20° 30'	0	0	0
Jun.	26	20° 29'	0	0	0
Jun.	27	20° 28'	0	0	0
Jun.	28	20° 27'	0	0	0
Jun.	29	20° 26'	0	0	0
Jun.	30	20° 25'	0	0	0
Jul.	1	20° 24'	0	0	0
Jul.	2	20° 23'	0	0	0
Jul.	3	20° 22'	0	0	0
Jul.	4	20° 21'	0	0	0
Jul.	5	20° 20'	0	0	0
Jul.	6	20° 19'	0	0	0
Jul.	7	20° 18'	0	0	0
Jul.	8	20° 17'	0	0	0
Jul.	9	20° 16'	0	0	0
Jul.	10	20° 15'	0	0	0
Jul.	11	20° 14'	0	0	0
Jul.	12	20° 13'	0	0	0
Jul.	13	20° 12'	0	0	0
Jul.	14	20° 11'	0	0	0
Jul.	15	20° 10'	0	0	0
Jul.	16	20° 9'	0	0	0
Jul.	17	20° 8'	0	0	0
Jul.	18	20° 7'	0	0	0
Jul.	19	20° 6'	0	0	0
Jul.	20	20° 5'	0	0	0
Jul.	21	20° 4'	0	0	0
Jul.	22	20° 3'	0	0	0
Jul.	23	20° 2'	0	0	0
Jul.	24	20° 1'	0	0	0
Jul.	25	19° 59'	0	0	0
Jul.	26	19° 58'	0	0	0
Jul.	27	19° 57'	0	0	0
Jul.	28	19° 56'	0	0	0
Jul.	29	19° 55'	0	0	0
Jul.	30	19° 54'	0	0	0
Aug.	1	19° 53'	0	0	0
Aug.	2	19° 52'	0	0	0
Aug.	3	19° 51'	0	0	0
Aug.	4	19° 50'	0	0	0
Aug.	5	19° 49'	0	0	0
Aug.	6	19° 48'	0	0	0
Aug.	7	19° 47'	0	0	0
Aug.	8	19° 46'	0	0	0
Aug.	9	19° 45'	0	0	0
Aug.	10	19° 44'	0	0	0
Aug.	11	19° 43'	0	0	0
Aug.	12	19° 42'	0	0	0
Aug.	13	19° 41'	0	0	0
Aug.	14	19° 40'	0	0	0
Aug.	15	19° 39'	0	0	0
Aug.	16	19° 38'	0	0	0
Aug.	17	19° 37'	0	0	0
Aug.	18	19° 36'	0	0	0
Aug.	19	19° 35'	0	0	0
Aug.	20	19° 34'	0	0	0
Aug.	21	19° 33'	0	0	0
Aug.	22	19° 32'	0	0	0
Aug.	23	19° 31'	0	0	0
Aug.	24	19° 30'	0	0	0
Aug.	25	19° 29'	0	0	0
Aug.	26	19° 28'	0	0	0
Aug.	27	19° 27'	0	0	0
Aug.	28	19° 26'	0	0	0
Aug.	29	19° 25'	0	0	0
Aug.	30	19° 24'	0	0	0
Sep.	1	19° 23'	0	0	0
Sep.	2	19° 22'	0	0	0
Sep.	3	19° 21'	0	0	0
Sep.	4	19° 20'	0	0	0
Sep.	5	19° 19'	0	0	0
Sep.	6	19° 18'	0	0	0
Sep.	7	19° 17'	0	0	0
Sep.	8	19° 16'	0	0	0
Sep.	9	19° 15'	0	0	0
Sep.	10	19° 14'	0	0	0
Sep.	11	19° 13'	0	0	0
Sep.	12	19° 12'	0	0	0
Sep.	13	19° 11'	0	0	0
Sep.	14	19° 10'	0	0	0
Sep.	15	19° 9'	0	0	0
Sep.	16	19° 8'	0	0	0
Sep.	17	19° 7'	0	0	0
Sep.	18	19° 6'	0	0	0
Sep.	19	19° 5'	0	0	0
Sep.	20	19° 4'	0	0	0
Sep.	21	19° 3'	0	0	0
Sep.	22	19° 2'	0	0	0
Sep.	23	19° 1'	0	0	0
Sep.	24	18° 59'	0	0	0
Sep.	25	18° 58'	0	0	0
Sep.	26	18° 57'	0	0	0
Sep.	27	18° 56'	0	0	0
Sep.	28	18° 55'	0		

A Table of the Sun's Declination.

First after Leap-Year, 1713. 1717.
1721. 1725.

M. D.	Jan.		Feb.		March.		April.		May.		June.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	39	13	South 39	3	South 17	8	North 43	18	North 9	23	North 11
2	21	28	13	South 19	2	South 53	9	North 5	18	North 24	23	North 15
3	21	18	12	South 59	2	South 29	9	North 26	18	North 39	23	North 18
4	21	7	12	38	2	5	9	47	18	53	23	21
5	20	57	12	17	1	42	10	9	19	7	23	23
6	20	44	11	56	1	18	10	30	19	21	23	25
7	20	32	11	35	0	54	10	51	19	34	23	27
8	20	19	11	14	0	31	11	12	19	46	23	28
9	20	6	10	53	0	7	11	32	20	0	23	29
10	19	53	10	31	North 16	11	53	20	12	23	30	30
11	19	38	10	9	0	40	12	13	20	24	23	30
12	19	25	9	47	1	4	12	33	20	36	23	29
13	19	11	9	25	1	27	12	53	20	48	23	28
14	18	56	9	3	1	51	13	13	20	59	23	27
15	18	41	8	40	2	14	13	32	21	9	23	25
16	18	26	8	18	2	38	13	51	21	19	23	23
17	18	10	7	55	3	1	14	10	21	29	23	20
18	17	54	7	32	3	25	14	29	21	39	23	17
19	17	38	7	10	3	48	14	47	21	48	23	14
20	17	21	6	47	4	11	15	6	21	57	23	10
21	17	4	6	24	4	34	15	24	22	5	23	6
22	16	47	6	1	4	57	15	42	22	13	23	1
23	16	29	5	37	5	20	15	59	22	21	22	56
24	16	12	5	14	5	43	16	16	22	28	22	51
25	15	53	4	51	6	6	16	33	22	35	22	45
26	15	35	4	27	6	29	16	50	22	41	22	39
27	15	16	4	4	6	51	17	6	22	47	22	32
28	14	57	3	40	7	14	17	23	22	53	22	25
29	14	38			7	36	17	38	22	58	22	18
30	14	19			7	58	17	54	23	3	22	10
31	13	59			8	21			23	7		

A Table of the Sun's Declination.

First after Leap-Year, 1713. 1717.
1721. 1725.

M. D.	July. D. M.	Aug. D. M.	Sept. D. M.	Octob. D. M.	Nov. D. M.	Dec. D. M.
1	22 North 2	15 North 2	4 North 12	7 South 25	17 South 46	23 South 8
2	21 North 53	14 North 44	3 North 49	7 South 48	18 South 2	23 South 12
3	21 North 44	14 North 25	3 North 26	8 South 10	18 South 18	23 South 16
4	21 35	14 7	3 3	8 33	18 33	23 20
5	21 25	13 48	2 46	8 55	18 48	23 22
6	21 15	13 29	2 16	9 17	19 3	23 24
7	20 5	13 9	1 53	9 39	19 18	23 26
8	20 54	12 50	1 30	10 1	19 32	23 28
9	20 43	12 30	1 6	10 23	19 46	23 29
10	20 33	12 10	0 43	10 44	19 59	23 30
11	20 20	11 50	0 19	11 6	20 12	23 30
12	20 8	11 30	South. 4	11 27	20 25	23 29
13	19 56	11 9	0 27	11 48	20 37	23 27
14	19 44	10 48	0 51	12 9	20 49	23 26
15	19 30	10 28	1 14	12 29	21 1	23 24
16	19 17	10 17	1 38	12 50	21 12	23 22
17	19 4	9 43	2 1	13 10	21 22	23 19
18	18 49	9 24	2 25	13 30	21 33	23 16
19	18 34	9 3	2 48	13 50	21 43	23 12
20	18 20	8 41	3 12	14 10	21 52	23 8
21	18 5	8 19	3 36	14 29	22 1	23 3
22	17 50	7 57	3 58	14 48	22 10	22 58
23	17 34	7 35	4 22	15 7	22 18	22 52
24	17 18	7 13	4 45	15 28	22 26	22 46
25	17 2	6 51	5 8	15 44	22 34	22 39
26	16 46	6 28	5 31	16 3	22 41	22 32
27	16 29	6 6	5 54	16 20	22 47	22 25
28	16 12	5 43	6 17	16 38	22 53	22 17
29	15 55	5 21	6 40	16 55	22 58	22 9
30	15 38	4 58	7 3	17 13	23 3	22 0
31	15 20	4 35		17 20	21	51

A Table of the Sun's Declination.

Second after Leap-Year, 1714. 1718.
1722. 1726.

M. D.	Jan.		Feb.		March.		April.		May.		June.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	41	13	44	3	22	8	37	18	6	23	10
2	21	31	13	24	2	59	8	59	18	21	23	14
3	21	21	13	4	2	35	9	21	18	35	23	17
4	21	10	12	43	2	11	9	42	18	50	23	20
5	20	59	12	21	1	48	10	3	19	4	23	23
6	20	47	12	1	1	24	10	25	19	18	23	25
7	20	35	11	40	1	0	10	46	19	31	23	26
8	20	22	11	19	0	37	11	7	19	44	23	28
9	20	10	10	58	0	13	11	27	19	57	23	29
10	19	56	10	36	North	10	11	48	20	10	23	30
11	19	43	10	14	0	34	12	1	20	22	23	30
12	19	29	9	52	0	58	12	28	20	33	23	29
13	19	15	9	30	1	21	12	48	20	45	23	28
14	19	0	9	8	1	45	13	8	20	56	23	27
15	18	45	8	46	2	8	13	27	21	7	23	25
16	18	30	8	23	2	32	13	47	21	19	23	23
17	18	24	8	1	2	55	14	6	21	27	23	21
18	17	58	7	38	3	18	14	24	21	36	23	18
19	17	42	7	15	3	42	14	43	21	45	23	14
20	17	25	6	52	4	5	15	1	21	54	23	11
21	17	8	6	29	4	29	15	19	22	3	23	7
22	16	51	6	6	4	52	15	37	22	11	23	2
23	16	34	5	43	5	15	15	55	22	19	22	57
24	16	16	5	20	5	38	16	12	22	26	22	52
25	15	58	4	57	6	1	16	11	22	33	22	46
26	15	39	4	33	6	23	16	46	22	40	22	40
27	15	21	4	9	6	46	17	2	22	46	22	34
28	15	2	3	46	7	8	17	19	22	51	22	27
29	14	43			7	31	17	35	22	57	22	20
30	14	23			7	53	17	50	23	2	22	12
31	14	4			8	15			23	6		

A Table of the Sun's Declination.

Second after Leap-Year, 1714. 1718.
1722. 1726.

M. D.	July.		Aug.		Sept.		Octo.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	12	4	15	6	4	North	18	7	20	17	South	7
2	21	53	14	48	3	North	55	7	42	17	South	11
3	21	40	14	30	3	North	32	8	5	18	South	15
4	21	37	14	11	3	North	8	8	37	18	South	19
5	21	28	13	52	2	North	45	8	30	18	South	22
6	21	18	13	33	2	North	22	9	13	18	South	24
7	21	8	13	14	1	North	59	9	34	19	South	26
8	20	57	12	54	1	North	35	9	56	19	South	28
9	20	46	12	35	1	North	12	10	17	19	South	28
10	20	35	12	15	0	North	48	10	40	20	South	29
11	20	23	11	55	0	North	25	11	0	20	South	30
12	20	11	11	35	0	North	2	11	22	20	South	29
13	20	0	11	14	South	22	11	43	20	34	South	28
14	19	46	10	53	0	South	49	12	3	20	South	27
15	19	35	10	33	1	South	9	12	24	20	South	25
16	19	20	10	12	1	South	32	12	45	21	South	22
17	19	6	9	51	1	South	56	13	5	21	South	19
18	18	52	9	29	2	South	19	13	25	21	South	16
19	18	38	9	8	2	South	42	13	45	21	South	12
20	18	23	8	46	3	South	6	14	5	21	South	9
21	18	8	8	25	3	South	29	14	24	21	South	4
22	17	43	8	3	3	South	53	14	44	22	South	59
23	17	38	7	41	4	South	16	15	3	22	South	53
24	17	23	7	19	4	South	39	15	22	22	South	47
25	17	6	6	56	5	South	2	15	40	22	South	41
26	16	50	6	34	5	South	25	15	58	22	South	34
27	16	31	6	12	5	South	48	16	16	22	South	27
28	16	16	5	49	6	South	11	16	34	22	South	19
29	15	59	5	26	6	South	34	16	51	22	South	11
30	15	42	5	4	6	South	57	17	8	23	South	2
31	15	24	4	41		South	17	25		21	South	53

A Table of the Sun's Declination.

The Third after Leap-Year, 1715.
1719 1723 1727.

M. D.	Jan.	Febr.	March.	April.	May.	June.
M. D.	D. M.	D. M.	D. M. M.	D. M.	D. M.	D. M.
1	21	43	28	8	18	23
2	21	33	3	8	18	23
3	21	23	2	9	18	23
4	21	12	1	9	18	23
5	21	1	1	9	19	23
6	20	50	1	10	19	23
7	20	38	1	10	19	23
8	20	29	0	11	19	23
9	20	18	0	11	19	23
10	20	0	0	11	20	23
11	19	46	0	12	20	23
12	19	32	0	12	20	23
13	19	18	1	12	20	23
14	19	4	1	13	20	23
15	18	49	2	13	21	23
16	18	37	2	13	21	23
17	18	18	2	14	21	23
18	18	2	3	14	21	23
19	17	46	3	14	21	23
20	17	29	4	14	21	23
21	17	13	4	15	22	23
22	17	55	4	15	22	23
23	16	38	5	15	22	23
24	16	20	5	16	22	23
25	16	2	5	16	22	23
26	15	44	6	16	22	23
27	15	25	6	16	22	23
28	15	7	7	17	22	23
29	14	48	7	17	22	23
30	14	28	7	17	23	23
31	14	9	8	1	23	23

A Table of the Sun's Declination

Third after Leap-Year, 1715. 1719.
1723. 1727.

M. D.	July. D. M.	Aug. D. M.	Sept. D. M.	Octob. D. M.	Nov. D. M.	Dec. D. M.
1	22 North 5	13 North 11	4 North 23	7 South 14	17 South 38	23 South 6
2	21 North 57	14 South 53	4 North 0	7 South 37	17 South 54	23 South 10
3	21 North 49	14 South 34	3 North 57	8 South 0	18 South 1	23 South 14
4	21 North 40	14 South 16	3 North 14	8 22	18 26	23 18
5	21 30	13 57	2 51	8 44	18 41	23 21
6	21 20	13 38	2 38	9 6	18 56	23 23
7	21 10	13 19	2 4	9 28	19 11	23 25
8	21 0	12 59	1 41	9 50	19 25	23 27
9	20 49	12 40	1 18	10 12	19 39	23 28
10	20 38	12 20	0 54	10 34	19 52	23 29
11	20 26	12 0	0 31	10 55	20 6	23 30
12	20 14	11 40	0 7	11 17	20 19	23 30
13	20 2	11 19	South 16	11 38	20 31	23 28
14	19 49	10 59	0 39	11 59	20 43	23 27
15	19 36	10 38	1 3	12 19	20 55	23 25
16	19 23	10 17	1 26	12 40	21 6	23 23
17	19 9	9 56	1 50	13 0	21 17	23 20
18	18 57	9 35	2 13	13 21	21 28	23 17
19	18 41	9 13	2 37	13 40	21 38	23 14
20	18 27	8 52	3 0	14 0	21 48	23 10
21	18 12	8 30	3 24	14 20	21 57	23 5
22	17 57	8 8	3 47	14 39	22 6	23 0
23	17 42	7 46	4 10	14 58	22 14	22 55
24	17 26	7 24	4 33	15 17	22 22	22 49
25	17 10	7 2	4 57	15 35	22 30	22 43
26	16 54	6 40	5 20	15 54	22 37	22 36
27	16 37	6 17	5 43	16 12	22 44	22 28
28	16 20	5 55	6 6	16 29	22 50	22 21
29	16 3	5 32	6 29	16 47	22 56	22 13
30	16 44	5 9	6 52	17 4	23 1	22 4
31	15 28	4 48		17 21		21 55

A Table of the Sun's Declination.

Leap-Year, 1716. 1720. 1724.
1728.

M. D.	Jan.		Feb.		March.		April.		May.		June.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	46	13	54	2	10	8	48	18	13	23	12
2	21	36	13	34	2	47	9	10	18	28	23	16
3	21	26	13	14	2	32	9	32	18	43	23	19
4	21	15	12	53	1	59	9	53	18	57	23	22
5	21	4	12	38	1	36	10	14	19	11	23	24
6	20	53	12	12	1	12	10	36	19	24	23	26
7	20	41	11	51	0	48	10	57	19	38	23	27
8	20	29	11	30	0	25	11	15	19	51	23	28
9	20	16	11	8	0	1	11	38	20	3	23	29
10	20	3	10	47	North	23	11	58	20	10	23	30
11	19	50	10	25	0	46	12	19	20	28	23	29
12	19	36	10	3	1	10	12	38	20	39	23	28
13	19	22	9	41	1	34	12	58	20	50	23	27
14	19	7	9	19	1	57	13	18	21	1	23	26
15	18	52	8	57	2	21	13	37	21	12	23	24
16	18	37	8	34	2	44	13	56	21	22	23	22
17	18	21	8	12	3	8	14	15	21	32	23	19
18	18	6	7	49	3	31	14	34	21	41	23	16
19	17	50	7	26	3	54	14	52	21	50	23	12
20	17	34	7	3	4	17	15	11	21	59	23	9
21	17	17	6	40	4	41	15	28	22	7	23	4
22	17	0	6	17	5	4	15	46	22	15	22	59
23	16	42	5	54	5	27	16	4	22	23	22	54
24	16	25	5	31	5	46	16	21	22	30	22	49
25	16	7	5	8	6	12	16	38	22	36	22	43
26	15	48	4	44	6	35	16	54	22	43	22	37
27	15	30	4	21	6	57	17	11	22	49	22	30
28	15	11	3	57	7	20	17	27	22	54	22	23
29	14	52	3	34	7	42	17	43	22	58	22	16
30	14	33			8	4	17	58	23	4	22	8
31	14	13			8	26			23	8		

A Table of the Sun's Declination.

Leap-Year, 1716. 1720. 1724.
1728.

M.D.	July.	Aug.	Sept.	Octob.	Nov.	Dec.
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
1	21 59	14 57	4 North 6	7 South 32	17 South 50	23 South 9
2	21 51	14 39	3 North 43	7 South 54	18 6	23 13
3	21 42	14 20	3 North 29	8 South 14	18 31	23 17
4	21 32	14 10	2 57	8 39	18 37	23 40
5	21 23	13 42	2 23	9 1	18 52	23 23
6	21 13	13 23	2 10	9 23	19 7	23 25
7	21 2	13 4	1 47	9 45	19 22	23 26
8	20 51	12 44	1 32	10 7	19 36	23 28
9	20 40	12 24	1 0	10 29	19 49	23 29
10	20 29	12 4	0 36	10 50	20 2	23 30
11	20 17	11 44	0 13	11 11	20 15	23 29
12	20 5	11 24	South 10	11 33	20 28	23 28
13	19 53	11 4	0 34	11 54	20 40	23 27
14	19 39	10 43	0 57	12 14	20 52	23 26
15	19 26	10 22	1 21	12 35	21 3	23 24
16	19 13	10 1	1 44	12 55	21 15	23 21
17	18 59	9 40	2 8	13 16	21 25	23 18
18	18 45	9 18	2 31	13 36	21 35	23 15
19	18 30	8 57	2 55	13 55	21 45	23 11
20	18 16	8 35	3 18	14 15	21 54	23 6
21	18 1	8 13	3 41	14 34	22 3	23 1
22	17 45	7 52	4 5	14 54	22 12	22 56
23	17 30	7 29	4 28	15 12	22 20	22 50
24	17 14	7 7	5 1	15 31	22 28	22 44
25	16 58	6 45	5 14	15 49	22 35	22 37
26	16 41	6 23	5 37	16 7	22 42	22 30
27	16 24	6 0	6 0	16 25	22 48	22 23
28	16 7	5 37	6 23	16 43	22 54	22 15
29	15 50	5 15	6 46	17 0	23 0	22 6
30	15 33	4 52	7 9	17 17	23 5	21 57
31	15 15	4 29		17 34		21 48

A Table of the Latitudes and Longitudes of the principal Ports, Harbours, Capes and Islands, in most of the known Parts of the World: Beginning from the Meridian of *Pico Teneriffa*. Collected from the best Charts, Descriptions, and Observations of several able and experienced Navigators of our own, and other Nations.

Places Names.		Latitude		Longit.		
		D.	M.	D.	M.	
The Sea Coast of Greenland.	H Aclutts Headland ———	79	50	N	26	55
	Fair Foreland ———	79	15	N	24	50
	Black Point ———	78	32	N	29	10
	Point Look out ———	76	25	N	32	00
	Cape Blanco ———	78	25	N	38	00
	Point Negro ———	77	10	N	42	00
	Hopeless Isles. ———	77	00	N	42	30
Islands in the North-Sea.	Hope Island ———	76	13	N	41	50
	Cherry Island ———	74	34	N	34	10
	S.-Point of Trinity Island ———	71	00	N	07	55
	Young's Foreland in Trinity Island ———	71	23	N	10	20
Sea-Coast of Nova-Zembla.	Orange Island ———	78	25	N	91	35
	Ice Point ———	77	45	N	90	50
	Admiralties Island ———	75	50	N	73	55
	Langeness ———	74	55	N	68	50
	Cross Point ———	72	25	N	68	05
	Prætorium Burrough ———	70	40	N	75	00
	The River Oby in the Tartarian Sea ———	69	12	N	80	49
	Mauritia's Isle. ———	71	24	N	72	10
Sea-Coast in the White-Sea.	Archangel ———	63	22	N	55	28
	Swelgenose ———	69	10	N	61	38
	Cape Candenose ———	69	35	N	58	02
	Orlogenosc ———	66	55	N	54	56

Fox

Fox

	Places Names.	Latitude.		Long.	
		D.	M.	D.	M.
Sea-Coast of Lapland and Norway.	Fox Nose	64	12	N	37 07
	Cape Grace	65	17	N	39 30
	Cape Gallant	67	11	N	39 32
	Cape Race	65	49	N	40 04
	Island Kilduyn	68	54	N	38 05
	North Cape	71	22	N	32 35
	Ross Isles	67	01	N	25 06
	Catsness	61	54	N	18 42
	Bomet	59	32	N	19 28
	Naze of Norway.	58	00	N	21 02
The Sea-Coast in the Sound.	The Nyding	57	00	N	25 40
	Cape Cole	56	46	N	26 12
	Scarlet Island	56	02	N	26 38
	Falsterborn	56	53	N	26 25
	Abbo	61	08	N	34 30
	Wyburrough	61	16	N	40 18
	Dagaret	59	44	N	34 31
	Dormamel	56	55	N	34 31
	Gotland	58	20	N	31 05
	Horsound	58	48	N	32 58
	Gothsund	59	15	N	32 29
	Earth-Holme	56	10	N	28 14
	Burnt-Holme	56	00	N	28 16
The Sea-Coast of Flind. from the Seaw to Callis.	Elfenore.	56	40	N	25 57
	The Schaw	57	52	N	24 27
	Bovenberg	56	20	N	23 56
	Holy Land	54	30	N	22 14
	The Texel	53	20	N	20 56
	The Brill	52	08	N	19 44
	Callis.	51	13	N	17 53

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	Places Names.	Latitude		Longit.	
		D.	M.	D.	M.
Sea-Coast of Iceland.	Langeness —————	67	20	N	003 45
	Grinse —————	67	00	N	352 05
	Maze —————	68	25	N	351 10
	Andifer —————	66	30	N	345 00
	Snowhill —————	65	40	N	344 40
	Alcra Point —————	64	08	N	344 20
	Westmonia Isles —————	63	35	N	349 00
	Merchants Foreland —————	63	36	N	358 40
	Whale's Back. —————	65	18	N	003 00
Islands near the Coast of Scotland.	St. Kilda —————	58	02	N	05 56
	Sky Island —————	57	40	N	10 08
	Lewis Island —————	58	30	N	08 00
	Fair Islands —————	61	43	N	09 00
	Sotland —————	60	22	N	14 50
	Fair Isle —————	59	30	N	14 20
	Isles of Orkney... —————	58	50	N	13 25
Sea-Coast of Scotland, England and Ireland.	Cateness —————	58	37	N	13 24
	Buchaness —————	58	00	N	14 32
	St. Abb's Head —————	56	25	N	14 12
	Tinmouth —————	55	08	N	15 00
	Flamborough Head —————	54	08	N	16 26
	The Sporne —————	53	45	N	16 58
	Wintertonness —————	52	52	N	18 00
	Orfordness —————	52	20	N	18 02
	The North Foreland —————	51	32	N	17 40
	The South Foreland —————	51	22	N	17 42
	Dongeness —————	51	09	N	17 14
	Isle of Wight —————	50	24	N	14 47
	Portland —————	50	20	N	13 46
	The Start —————	50	27	N	13 09
	The Lizard —————	50	00	N	12 37
	Islands of Silly —————	50	07	N	09 47
	Londy Isle —————	51	22	N	11 57
	St. David's Head. —————	51	54	N	11 18

Bradley

Places Names.	Latitude.		Longit.	
	D.	M.	D.	M.
Bradsey Isle	52	46 N	01	93
Holy Head	54	44 N	11	44
Isle of Man	54	25 N	11	45
Coswells Point	54	36 N	11	18
Fair Foreland	55	35 N	10	16
Aron Isle	53	21 N	08	30
Black Rock	53	52 N	06	00
Slins Head	53	16 N	06	00
Blasques	52	15 N	05	20
Cape Clear	51	15 N	06	28
Old Head	51	40 N	07	32
Hearn Point.	52	05 N	10	04
Sain Head	50	04 N	16	50
Cape Hague	50	04 N	15	05
Caskets	50	07 N	14	30
Garnsey	49	43 N	14	20
Ferfy	49	30 N	14	46
Ushant	48	40 N	11	16
Oleroon	45	58 N	11	00
Cape de Machicaca	44	22 N	14	20
Cape Pinas	44	04 N	11	10
Cape Ortegal	44	08 N	09	16
Cape Finisterre	43	10 N	06	58
The Rock of Lisbon	38	52 N	06	43
Cape St. Vincent	37	00 N	07	20
Cape St. Maria	37	05 N	08	42
The Straits of Gibralter.	36	00 N	10	40

Sea-Coast of Scotland, England, and Ireland.

Sea-Coast of France, Spain, and Portugal.

The Sea Coasts on the Main-Continent in the Straits.

Islands within
the Straits.

Places Names.

Latitude.

Longit.

D. M.

D. M.

Cape de Gata	36	47	N	16	08
Cape St. Martin	38	46	N	18	57
Cape Daga Frito	41	41	N	21	49
Cape Larei	42	58	N	24	28
Cape Melle	43	51	N	26	21
Terraciana	41	26	N	31	26
Cape Spartaventura	37	46	N	36	06
Cape Collom	38	50	N	37	30
Cape St. Maria	39	52	N	38	16
Angello	41	31	N	36	28
Ancana	43	25	N	32	40
Cape Cesta	43	27	N	34	55
Ragusa	42	29	N	37	36
Cape Linga	40	19	N	38	50
Cape Matopan	36	28	N	42	00
Cape St. Angelo	37	15	N	42	56
Cape Doro	39	14	N	45	12
Cape Barbarnou	37	58	N	46	19
Cape Saradoni	35	35	N	48	46
Cape Pollopollo	34	54	N	55	34
Cape de Becur	32	40	N	50	48
Cape Roatini	32	18	N	43	32
Cape Rozato	32	58	N	40	28
Cape Bona	37	05	N	30	12
Collo	37	09	N	24	52
Punis	36	40	N	19	46
Cape Falcon	36	08	N	17	28
Cape Tres Forcas	35	40	N	15	24
Tangier	35	36	N	11	35

Alboran	37	52	N	15	18
Formentara	38	44	N	19	38
Ivica	39	05	N	19	50
Majorca	39	38	N	21	20
Minorca	39	55	N	22	30

Gallatta

Places Names.	Latitude.		Longi.	
	D.	M.	D.	M.
Gallatta	37	57 N	27	50
Cape Palo in Sardinia	38	56 N	27	36
Cape Corso in Corsica	42	51 N	27	32
Lilbo	42	51 N	29	00
Palagrolla	40	50 N	31	12
Ustica	38	46 N	32	48
Maritimo	37	52 N	30	54
Pantalavia	36	53 N	31	00
Limpadofa	35	58 N	31	52
Limosfa	36	25 N	32	05
Malta	36	00 N	33	12
Cape Passaro in Sicilia	37	10 N	34	51
Messina	38	07 N	35	08
Lissa	43	00 N	35	22
Trinity	41	50 N	35	14
Palagofa	42	17 N	35	50
Augusta	42	36 N	36	12
Mallida	42	37 N	37	04
Corfu	39	25 N	39	18
Cephalonia	38	28 N	40	29
Zant	37	37 N	40	40
West End of Candia	35	15 N	43	00
East End of Candia	35	04 N	46	28
Rhodes	35	40 N	48	00
West End of Cyprus	34	22 N	51	34
East End of Cyprus	34	48 N	54	35
Cape Spartel	35	38 N	11	35
Cape Cantin	32	27 N	07	35
Cape Bojador	26	55 N	02	24
Cape Blanc	20	32 N	358	56
Cape Verde	14	36 N	358	50
Sirre Leone	08	00 N	03	32
The S. Side of St. Anne	06	40 N	01	11
				Cape

Islands within the Straits.

Sea-Coast of Barbary and Guiny.

Places Names.		Latitude.	Longi.
		D. M.	D. M.
Sea-Coast of Barbary and Guiny.	Cape de Palmas —————	04 10 N	10 00
	Cape Tres Puntas —————	04 06 N	16 00
	Cape Formosa —————	04 10 N	24 10
	The N. Point of Fernando	03 25 N	27 20
	Island Principas —————	01 50 N	28 20
	Island Chocos —————	00 40 N	03 32
	Island St. Thomas —————	00 10 N	27 30
	Cape Lupus —————	01 00 S	27 40
	Cape Negro —————	16 00 S	30 50
	Cape Sacos —————	29 40 S	36 20
	Cape Bona Esperanza —————	34 24 S	38 10
Western Islands.	The West-side of Corua	40 00 N	345 30
	The West-side of Flores	39 40 N	345 30
	The Road before Fyal —	38 50 N	347 47
	The West-End of Pico	38 40 N	348 18
	W. End of St. George —	39 00 N	348 30
	W. End of Tercera —	30 00 N	349 10
	E. End of St. Michael's	38 00 N	351 40
The Canary Islands.	E. End of St. Maries	37 00 N	351 30
	N. Part of Ferro ———	27 40 N	358 25
	E. Side of Palme ———	28 36 N	358 43
	Gomera —————	28 10 N	359 15
	Pico Teneriffa ———	28 20 N	00 00
	The E. End of Madera	32 32 N	00 10
	E. End of Port Sancto —	33 00 N	01 00
	N. E. Point of Canaria —	28 10 N	01 00
	N. E. P. of Forteventura	28 20 N	02 50
	E. Part of Lancerotta —	28 30 N	03 10

The

A Table of Latitude and Longitude. 315

Places Names.		Latitude.		Longit.	
		D.	M.	D.	M.
<i>Cape de Verde Islands.</i>					
The West side of <i>Antonio</i>		17	00	N	350 00
East-Point of <i>St. Vincent</i>		17	40	N	350 08
East-side of <i>St. Lucia</i> —		16	50	N	351 40
Isle <i>Brava</i> ———		14	40	N	351 08
Isle <i>Fogo</i> ———		14	00	N	351 30
East-side of <i>St. Jago</i> —		15	00	N	352 30
The Side of <i>de Mopo</i> Isle		15	00	N	353 04
East-side of the Isle of <i>Sal</i>		16	00	N	353 04
East-side of <i>Bona Vista</i> —		16	00	N	353 04
St. <i>Matthews</i> ———		01	40	S	11 32
Island <i>Anabona</i> ———		01	22	S	26 20
<i>Ascension</i> ———		08	00	S	04 30
St. <i>Helena</i> ———		16	00	S	13 50
St. <i>Helena Nova</i> ———		16	03	S	24 48
Island <i>Degialica</i> ———		37	56	S	12 00
Island <i>Desjstian</i> ———		36	57	S	12 42
<i>Cape Anquilbas</i> ———		35	00	S	39 30
<i>Cape Corientes</i> ———		23	30	S	56 00
<i>Cape de Guada</i> ———		15	17	S	59 56
<i>Cape de Guardasin</i> ———		11	40	N	74 15
<i>Cape de Rasalgate</i> ———		22	07	N	84 10
<i>Surat</i> ———		21	04	N	96 20
Goa ———		15	40	N	97 00
<i>Cape Comerin</i> ———		07	52	N	99 12
S. W. Point of <i>Ceylon</i> —		06	00	N	101 56
<i>River Bengale</i> ———		22	09	N	110 20
<i>River de Care</i> ———		10	45	N	119 10
<i>Johr</i> ———		01	25	N	125 06
<i>Siam</i> ———		14	52	N	122 45

Cambodia

316 *A Table of Latitude and Longitude.*

	Places Names.	Latitude.		Long
		D.	M.	
Sea-Coast on the Main-Continent in East-India.	Cambodia —————	12	42 N	126 0
	Vischers Point —————	20	18 N	131 0
	The Point of Cavallos ———	25	16 N	140 8
	Cape Sember —————	28	07 N	142 8
	Ninghai —————	36	40 N	142 2
	Corea. —————	36	05 N	146 0
Islands in the East India.	Rimeyros —————	28	19 S	89 4
	John de Lisbon —————	25	24 S	75 8
	Diego Roix —————	20	05 S	85 0
	St. Brande —————	17	13 S	87 5
	Dolgasias —————	15	20 S	82 1
	Moroslas —————	20	10 S	78 3
	Domascaicaes —————	20	50 S	74 0
	St. Apollonia —————	20	50 S	74 0
	South end of St. Lawrence ———	25	37 S	68 0
	North-end of St. Lawrence ———	11	03 S	73 0
	Bastos de India —————	22	10 S	60 4
	John de Nova —————	17	20 S	63 19
	Mayotta —————	12	40 S	66 30
	Comore —————	11	20 S	65 10
	De Natal —————	08	20 S	68 05
	Cosmoled —————	09	40 S	72 08
	John de Nova —————	09	00 S	79 46
	De Almiranta —————	03	57 S	76 00
	Domescaicubas —————	03	21 S	80 26
	St. Hermanas —————	03	02 S	84 00
	Diego Gratiota —————	08	03 S	92 20
	De Gamo —————	02	40 S	99 05
	Adu —————	05	39 S	99 00
	Apeluria —————	09	20 S	100 40
	Island Pracel —————	10	23 N	93 14

Cubile

Islands in the East-India.

A Table of Latitude and Longitude. 317

Places Names.	Latitude.		Longit.	
	D.	M.	D.	M.
Cubile	8	53 N	93	30
Molique	9	05 N	94	25
Andaro	11	30 N	95	38
N. W. Point of Sumatra	5	30 N	116	00
S. East. end of Sumatra	5	52 S	125	40
Bantan	6	15 S	126	30
Batavia	6	10 S	127	05
Combava	8	36 S	138	00
Flores	8	50 S	140	48
Timor	9	52 S	145	53
Geran	3	26 S	148	20
Amboina	3	52 S	147	25
South-end of Celebes	5	45 S	139	30
North Point of Celebes	2	16 N	144	06
The Middle of Gilolo	0	00 X	147	20
Bachian	0	03 N	146	10
Machian	0	14 N	146	06
Motir	0	25 N	146	08
Pottobackers	0	32 N	146	10
Tidore	0	41 N	146	16
Miserva	0	43 N	146	14
Ternate	0	47 N	146	12
St. Johannes	4	10 N	138	50
South Point of Borneo	4	16 S	135	04
North Point of Borneo	7	40 N	134	35
West-end of Mindano	6	50 N	141	25
Anamba	2	38 N	126	42
Natara	3	30 N	127	45
St. Juan	8	16 N	146	20
Tindai	12	00 N	145	05
Masbat	11	50 N	143	35
Sebu	9	55 N	143	10
Pandi	11	05 N	142	00
Mindora	12	50 N	140	28
Paragoa	9	40 N	136	30
South-end of Lucon	12	42 N	143	45

North

	Places Names.	Latitude.		Longitude.	
		D. M.		D. M.	
Islands in the East-India.	North-end of Lucon —	18	42 N	141	5
	The Middle of Aynam —	19	00 N	131	0
	South end of Formosa —	21	20 N	142	0
	North end of Formosa —	28	10 N	143	1
	Rivando Isle —	33	00 N	157	1
	West-end of Japan —	34	00 N	150	0
	North-end of Cikoko —	34	05 N	150	1
	Tonsa —	33	25 N	153	0
	North-Point of Japan —	40	05 N	163	2
	Cape Eroen in Jesso —	42	50 N	183	2
	Cape Patience in Jesso —	49	00 N	186	0
The Coast of America in the South-Sea.	The Straits of Anian —	57	10 N	251	5
	Cape Blanco —	42	00 N	245	10
	Sir Francis Drake's Bay —	38	16 N	246	3
	Island Pararos —	30	08 N	253	5
	Cape St. Lucas —	23	10 N	266	10
	Cape Corientes —	20	28 N	270	5
	Aquatulco —	16	45 N	282	5
	Gulf of Salina —	10	00 N	288	2
	Cape St. Maria —	07	08 N	293	0
	Cape Corintas —	05	26 N	295	2
	Cape de Francisco —	01	25 N	292	2
	Cape de Passao —	00	00 X	291	3
	Payta —	04	30 S	293	0
	Truxilla —	08	05 S	295	0
	Villa la Nasca —	15	10 S	297	5
	Arica —	18	35 S	202	0
	Island Ferando —	33	47 S	292	20
	Baldivia —	40	00 S	297	3
	P. St. Cyprian —	43	16 S	296	3
	W. Entrance of Magellan —	53	00 S	296	4
	Cape Horn —	57	54 S	303	0
				Honde	

A Table of Latitude and Longitude. 319

Places Names.	Latitude.		Longit.	
	D.	M.	D.	M.
<i>Ilands in the Great South-Sea.</i>				
Honder Island	14	00 S	237	30
Water Islands	14	50 S	229	00
Island Tiburones	12	00 S	218	05
St. Pedro	22	10 S	229	10
Prince William's Islands	18	14 S	204	50
Islands of Good Hope	17	12 S	195	40
States Land	38	60 S	192	00
Green Islands	04	00 S	172	00
Salteadores Isles	06	40 N	172	05
Miracomo	06	24 N	175	40
Island de Ladrones	10	00 N	170	00
Nadadores	04	22 N	186	55
Barbadoes Isles	07	00 N	195	05
St. Peter's Isle	11	14 N	205	00
Harmanes Isle	15	10 N	181	05
<i>Sea-Coast on the Main Continent of America.</i>				
Lamairs Strait	55	00 S	310	16
Cape Pennas	53	45 S	307	20
East Entrance of Magellan	52	20 S	305	00
Cape Blanco	47	30 S	309	45
Cape St. Antonie	36	38 S	325	00
Cape St. Maria	35	00 S	325	40
Cape Frio	22	52 S	338	38
Baja de todos Santos	13	00 S	341	50
Cape St. Augustin	08	40 S	345	40
Black Point	03	10 S	343	00
River Cassepore	04	00 N	328	05
Suranam	05	05 N	323	40
Cape three Points	11	18 N	314	20
Cape de Coquibocao	12	42 N	305	24
Carthagene	10	25 N	298	25
Cape de Gracias	15	32 N	291	55
Cape de Catoche	21	23 N	287	00
Cape Rexo	22	40 N	275	26
Cape Blanco	26	55 N	274	56
			Cape	

	Places Names.	Latitude.			Longitude.
		D.	M.	N.	
Sea Coast on the Main-Continent of America.	Cape Escondido	29	52	N	285 4
	La Florida	25	51	N	272 1
	Cape Fair	34	02	N	298 2
	Cape Henry	37	00	N	300 4
	Cape Charles	37	48	N	300 5
	Cape May	39	55	N	302 6
	The East-end of long Island	40	45	N	303 1
	Cape Cod	42	20	N	308 4
	Cape Ann	42	45	N	308 1
	Cape Furcu	44	00	N	314 1
	East-end of Isle of Sables	43	40	N	323 0
	Cape Britain	45	30	N	323 1
	Cape Raze	46	36	N	328 3
	Conception Bay	48	22	N	327 5
	Bay of Bulls	47	27	N	328 0
	Cape Bona Vista	49	19	N	328 3
	Penguins Isle	50	02	N	328 4
Islands in the West-India.	Cape Gate	52	00	N	325 3
	Bell Isle.	52	25	N	325 3
	Bermudas	32	18	N	310 5
	Bebama	27	57	N	295 20
	N.E. Point of Lucaonique	27	52	N	298 20
	Signateo	26	18	N	300 00
	Guatro	25	47	N	301 00
	Guamina	25	15	N	301 40
	Tiango	24	33	N	302 20
	Majagana	23	05	N	303 00
	Caicos	22	05	N	304 05
	Ithagua	21	19	N	301 40
	Tamata	22	32	N	301 20
	Samana	24	20	N	295 45
	Tamia	24	30	N	301 05

Anguilla

A Table of Latitude and Longitude. 321

Places Names.	Latitude			Longi.	
	D.	M.		D.	M.
Anguilla	18	48	N	313	35
St. Christophers	17	30	N	313	30
South-end of Barbada	17	36	N	316	00
Antego	16	32	N	315	10
Guardalupa	16	00	N	314	40
Marigallanta	15	41	N	315	25
Dominica	15	00	N	314	50
Martinico	14	30	N	316	36
St. Lucia	13	13	N	315	20
Barbadoes	13	12	N	319	40
St. Vincent	12	50	N	313	45
Granada	12	10	N	314	40
Tobago	11	12	N	317	00
Point de Gallai	10	45	N	316	55
Nevis	17	00	N	314	00
Monserat	16	20	N	314	20
Margaretta	11	28	N	312	25
Tortogas	11	30	N	313	30
Doikilla	12	19	N	310	30
Bonayre	12	32	N	308	35
Quiffa	12	25	N	307	30
East-end of Hispaniola	18	47	N	308	10
West-end of Hispaniola	18	25	N	300	10
Port-Royal in Jamaica	18	15	N	297	10
East-end of Cuba	20	27	N	301	20
West-end of Cuba	22	00	N	288	26
Camnamis	19	41	N	294	45
Great Caiman	19	21	N	293	30
Santa Villa	17	28	N	294	00
Mosquito	14	50	N	294	12
Guanabo	16	33	N	287	14
Guanabimo	16	10	N	286	20
Cezumal	19	25	N	287	10
Lasalleiranes	22	00	N	284	40

Islands in the West-India.

Z

Cape

	Places Names.	Latitude.		Longit.	
		D.	M.	D.	M.
<i>The Northern Parts of America.</i>	<i>Cape Camas</i> —————	53	40 N	226	52
	<i>Resolution Isles</i> —————	61	00 N	309	00
	<i>The King's Foreland</i> —————	61	50 N	295	30
	<i>Queen Ann's Foreland</i> —————	63	52 N	293	40
	<i>Cape Charles</i> —————	62	55 N	291	42
	<i>N. end of Mansfield's Isle</i> —————	62	40 N	284	39
	<i>Prince Rupert's River</i> —————	51	00 N	289	12
	<i>Cape Monmouth</i> —————	54	40 N	283	00
	<i>Cape Henrietta</i> —————	56	16 N	279	10
	<i>Port Nelson</i> —————	58	32 N	267	50
	<i>Cape Southampton</i> —————	62	30 N	279	25
	<i>Sea-borse Point</i> —————	64	46 N	282	20
	<i>Sir Dudley Digg's Cape</i> —————	75	10 N	298	00
	<i>Sanderson's Tower</i> —————	68	00 N	314	08
	<i>Cape Walsingham</i> —————	65	42 N	311	20
	<i>Cape Comfort</i> —————	62	21 N	321	20
	<i>Cape Desolation</i> —————	61	20 N	325	05
	<i>Cape Farewel.</i> —————	59	45 N	329	02

A Table of the Declination and Ascension of the principal Fixed Stars.

Names of the Stars.	Mag	Ri Af.		Declin.	
		D.	M. H.	M.	
Pole Star	2	0	3287	33	N
Girdle of Andromeda	2	0	5033	50	N
Medusaes head	2	2	442	42	N
Perseus Right Side	2	2	5948	33	N
Bull's Eye Aldebaran	1	4	165	46	N
Goat Capella	1	4	5245	37	N
Orion's Left Foot	1	4	588	38	S
Orion's Left Shoulder	3	5	65	59	N
Middle Star in Orion's Belt	3	5	191	27	S
Orion's Right Shoulder	2	5	367	18	N
Waggoner	2	5	3944	56	N
Syrius the Great Dog	1	6	3016	33	S
Castor	2	7	1232	30	N
Procyon the Little Dog	2	7	22	6	N
Pollux	2	7	2428	28	N
Hydraes Heart	1	9	107	10	S
Lyon's neck	1	9	5021	41	N
Lyon's Heart	1	9	5013	39	N
Lyon's Tail	1	11	3116	30	N
Virgin's Girdle	3	12	38	5	N
Virgin's Spike	1	13	7	9	S
Arcturus	1	14	021	3	N
South Ballance	2	14	3214	33	S
North Ballance	3	15	588	3	S
Scorpion's Heart	1	16	825	35	S
Head of Ophincus	2	17	2212	48	N
Brightest in the Harp	1	18	2538	30	N
Vulture's Heart	2	19	348	0	N
Swan's Tail	2	20	3044	5	N
Pegasus Mouth	3	21	278	19	N
Pomahant	1	22	3931	17	S
Marchab	2	22	5013	40	N
Pegasus lower Wing	2	23	5533	25	N

A Table of the Sun's Right Ascension.

Month	Jan.	Feb.	Mar.	April	May	June
Days.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	19 35	21 42	23 28	I 25	3 18	5 23
2	19 39	21 46	23 31	I 29	3 22	5 27
3	19 43	21 50	23 35	I 33	3 26	5 31
4	19 47	21 54	23 39	I 36	3 30	5 36
5	19 51	21 58	23 43	I 40	3 34	5 40
6	19 56	22 2	23 46	I 44	3 38	5 44
7	20 0	22 6	23 50	I 47	3 42	5 48
8	20 4	22 10	23 54	I 51	3 46	5 52
9	20 9	22 14	23 58	I 54	3 50	5 56
10	20 13	22 17	0 2	I 58	3 54	6 0
11	20 17	22 21	0 6	2 2	3 58	6 4
12	20 22	22 25	0 10	2 6	4 2	6 8
13	20 26	22 29	0 13	2 10	4 6	6 12
14	20 30	22 33	0 17	2 13	4 10	6 17
15	20 34	22 36	0 21	2 17	4 14	6 21
16	20 38	22 40	0 25	2 21	4 18	6 25
17	20 42	22 44	0 29	2 25	4 22	6 29
18	20 46	22 48	0 32	2 29	4 26	6 33
19	20 50	22 52	0 36	2 32	4 30	6 38
20	20 54	22 55	0 40	2 36	4 34	6 42
21	20 58	22 59	0 44	2 40	4 38	6 46
22	21 3	23 3	0 48	2 44	4 42	6 50
23	21 7	23 6	0 51	2 48	4 46	6 54
24	21 11	23 10	0 55	2 51	4 50	6 58
25	21 15	23 13	0 59	2 55	4 54	7 2
26	21 19	23 17	I 3	2 59	4 58	7 6
27	21 23	23 21	I 6	3 3	5 2	7 10
28	21 27	23 25	I 10	3 7	5 6	7 14
29	21 31		I 14	3 10	5 11	7 19
30	21 35		I 17	3 14	5 15	7 23
31	21 38		I 21		5 19	

A Table of the Sun's Right Ascension.

Month	July	Aug	Sept.	Octo.	Nov.	Dec.
Days	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	7 27	9 29	11 23	13 12	15 11	17 19
2	7 31	9 33	11 26	13 15	15 15	17 24
3	7 35	9 37	11 30	13 19	15 19	17 28
4	7 39	9 40	11 33	13 22	15 23	17 33
5	7 43	9 44	11 37	13 26	15 27	17 37
6	7 47	9 48	11 41	13 30	15 31	17 41
7	7 51	9 51	11 44	13 34	15 35	17 46
8	7 55	9 55	11 48	13 38	15 39	17 50
9	7 59	9 58	11 51	13 41	15 44	17 54
10	8 3	10 2	11 55	13 45	15 48	17 58
11	8 7	10 6	11 59	13 49	15 53	18 3
12	8 11	10 10	12 2	13 53	15 57	18 7
13	8 15	10 14	12 6	13 57	16 2	18 12
14	8 19	10 17	12 9	14 0	16 6	18 17
15	8 23	10 21	12 13	14 4	16 11	18 22
16	8 27	10 25	12 17	14 8	16 15	18 26
17	8 31	10 28	12 20	14 12	16 19	18 31
18	8 35	10 32	12 24	14 16	16 23	18 35
19	8 39	10 35	12 27	14 20	16 28	18 39
20	8 43	10 39	12 31	14 24	16 32	18 43
21	8 47	10 43	12 35	14 28	16 36	18 47
22	8 51	10 46	12 38	14 32	16 40	18 51
23	8 55	10 50	12 42	14 36	16 44	18 55
24	8 59	10 53	12 45	14 39	16 49	19 0
25	9 2	10 57	12 49	14 43	16 53	19 4
26	9 6	11 1	12 53	14 47	16 57	19 8
27	9 10	11 4	12 57	14 51	17 1	19 13
28	9 14	11 8	13 1	14 55	17 5	19 17
29	9 17	11 11	13 4	14 59	17 0	19 22
30	9 21	11 15	13 8	15 3	17 14	19 26
31	9 25	11 19		15 7		19 30

*The Use of the Table of Fixed Stars, and Sun's
Right Ascension.*

FIRST, Suppose you see a Star upon the Meridian, and know not what Star it is, see for the Sun's Right Ascension the Day proposed, and to that add the Hour of the Night when the Star is upon the Meridian, casting away 24, if it exceeds; and for that sum look in the Table of Fixed Stars, under [Right Ascension,] and the Star against which it stands is the Star that you saw upon the Meridian.

Example. December 31, at 11 at Night, I see a Star upon the Meridian, which I suppose to be of the First Magnitude, viz. one of the Biggest of the Fixed Stars; I find the Sun's Right Ascension that Day 19 30, to which add the Hour of the Night, 11, the Sum is 30 30; but casting away 24, there Rems 6 30, which I look for in the Table of Fixed Stars, under [Right Ascension] and find it to stand against *Syrus*, the *Great Dog*, so I know it is the *Great Dog* that I saw upon the Meridian, which is a Star of the first Magnitude: And so in others.

But if you know a Star, and desire to know what Time it will be upon the Meridian, subtract the Right Ascension of the Sun that Day from the Right Ascension of the Star mentioned in the Table (Borrowing 24, if need be) the Remainder is the Time of the Star's Coming to the Meridian. *Example*; I desire to know what Time the *Great Dog* comes to South February the First, the Sun's Right Ascension that Day is 21, 42, which subtracted from 6 30, (the Right Ascension of the *Great Dog*) by adding 24, because it cannot be done otherways, the Sum is 30 30, from which take 21 42, the Remainder 8 48 is the Hour of the Night that the *Great Dog* comes to the South.

Again: If you see a known Star upon the Meridi-

The Use of the Table of Fixed Stars, &c. 327

and desire thereby to know the Time of the Night, you may presently know what Hour it is by the above said Rule; and in common Cases, if you know the Time of a known Star's coming to the Meridian, you may nearly compute it by Allowing 4 Minutes to every Day. *Example*: I have found, as above, that the *Great Dog* souths *February* the First, at 48 Minutes past 8 at Night; And seeing the same Star upon the Meridian *February* the 9th, I desire to know the Hour of the Night; now from *February* 1 to *February* 9, is 8 Days, which, allowing 4 Minutes a Day, amounts to 32 Minutes, which subtracted from 8 Hours, 48 Minutes, the Time of the *Great Dog's* Southing *February* the First, the Remainder 8 Hours, 16 Minutes, is the Time of the *Great Dog's* Southing *February* the Ninth. This Allowance of 4 Minutes a Day may serve for common Use, but if you would be exact, work by the preceeding Rules.

In the last Column of the Table, you have the Declination of the Fixed Stars, which is of Use in taking an Observation: Of which, see more in Chap. 7. Sect. 1. of this Treatise.

The Magnitude is of Use to know the Bigness of a Star; a Star of the first Magnitude, being the biggest; the sixth the least; and the rest of Bigness proportionable to their Magnitudes express'd in the Table.

*A Table of the Angles, which every Rhomb
(or Point of the Compass) maketh with
the Meridian.*

NORTH.	SOUTH.	Points.	D.M.	NORTH.	SOUTH.
		$\frac{1}{4}$	02 49		
		$\frac{1}{2}$	05 37		
		$\frac{3}{4}$	08 26		
North by East	South by East	1	11 15	N. by W.	S. by W.
		$\frac{1}{4}$	14 04		
		$\frac{1}{2}$	16 52		
		$\frac{3}{4}$	19 41		
N. N. E.	S. S. E.	2	22 30	N. N. W.	S. S. W.
		$\frac{1}{4}$	25 19		
		$\frac{1}{2}$	28 07		
		$\frac{3}{4}$	30 56		
N. E. by N.	S. E. by S.	3	33 45	N. W. by N.	S. W. by S.
		$\frac{1}{4}$	36 34		
		$\frac{1}{2}$	39 22		
		$\frac{3}{4}$	42 11		
North East.	South-East.	4	45 00	North-West.	South-West.
		$\frac{1}{4}$	47 49		
		$\frac{1}{2}$	50 37		
		$\frac{3}{4}$	53 26		
N. E. by E.	S. E. by E.	5	56 15	N. W. by W.	S. W. by W.
		$\frac{1}{4}$	59 04		
		$\frac{1}{2}$	61 52		
		$\frac{3}{4}$	64 42		
E. N. E.	E. S. E.	6	67 30	W. N. W.	W. S. W.
		$\frac{1}{4}$	70 19		
		$\frac{1}{2}$	73 07		
		$\frac{3}{4}$	75 56		
East by North	East by South	7	78 45	W. by N.	W. by S.
		$\frac{1}{4}$	81 34		
		$\frac{1}{2}$	84 22		
		$\frac{3}{4}$	87 11		
East.	East.	8	90 00	West.	West.

APPENDIX,

Containing several Pleasant and useful Questions, and first of Currents.

IN Sailing in a Current it is very evident, that a Ship doth not make her Way good according to the Course steered by the Compass, and the Distance run by the Log, but being at the same Time privately carried by a Current, her true Course and Distance is compounded of the Course and Distance sail'd, and of the Course and Motion of the Current; therefore where both these are given, you must first lay down the Course and Dist. sail'd, and from that the Course and Motion of the Current; and the Course and Distance from the Place sail'd from, to this last Place thus found, is the true Course and Distance made good as in the first Question following: A Ship sails S.E. 100 Miles from *C* to *A*, and a Current sets in the same time West 30 Miles; now if there was no Current, the true Course and Distance of the Ship would be represented by the Line *CA* and the Point *A*, should represent the Place sail'd to, but because a Current sets West 30 Miles, in the same time, I set off 30 Miles W. from *A* to *D* and the Point *D*, represents the Place sail'd to, and the Line *CD* is the true Course and Dist. made good; and hence in every Question in Currents, there is constituted a plain Triangle, either Right Angled, or Oblique, the Angles of which some call the Angles of

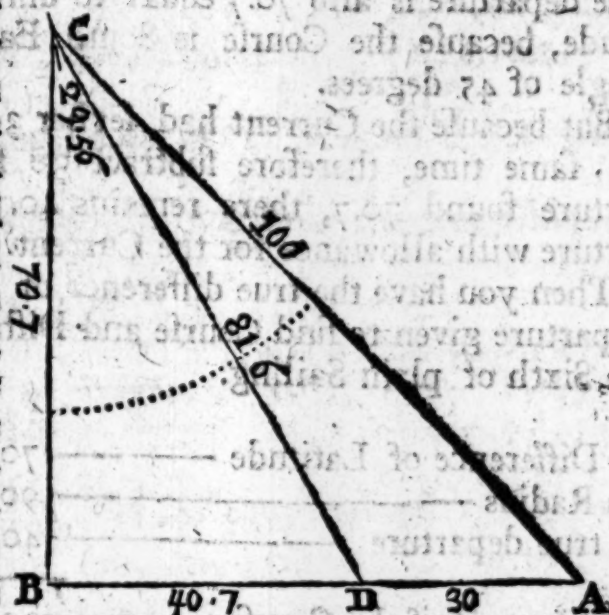
of Reflection, Deflection, and Incidence, as Mr. Norwood in his *Seaman's Practice*; but by the Learned Mr. T. P. more properly the Angle of Force, the Angle of Submission, and the Angle of Chance: But I shall not trouble the Learners Memory with these Terms, but call them as indeed they are, the Course steered, or the Course made good &c. And therefore, *Note*. That by the Course, or the Course steered, I mean the Course by the Compass, and by the Distance, I mean the Distance by the Log, but by Course and Distance made good, I mean the true Course and Distance of the Ship, from the Place sail'd from, to the Place come to, with Allowance for the Current, &c.

There are several Cases and Varieties in Currents, but Three are chiefly useful: The First is, when the Course and Distance is given, with the Course and Motion of the Current also given, to find the Course and Distance made good. The Second is, when the Course and Distance sail'd, and Course and Distance made good is given to find the Course and Motion of the Current. The Third is, when the Course and Distance made good, and Course and Motion of the Current is given, to find the Course and Distance sail'd, and this is of great Use when the Bearing and Distance of two Ports or Islands are given, and the Course and Motion of a Current between them is also given, to find how much to lay your Ship to the Windward of her true Course, that so the Set of Current with that Course steered may just bring her to the proposed Port.

Case I. Course and Distance sail'd, and Course and Motion of the Current given, to find the Course and Distance made good.

A Ship Sails S. E. 100 Miles in 24 Hours in a Current that sets West 30 Miles in the same time, Demand what is the true Course and Distance made good in 24

Geometrical Construction.



Hours time, with the Course S. E. and Distance 100 lay it down as in plain Sail- ing Geome- trical, and when it will appear as in the Triangle, ABC, and the Ship should be at A; but be- cause the Cur- rent sets 30 Miles West in B the same time, set off 30 Miles from A to D because from A to D is West; then is the true Place of the Ship at D; therefore draw the Line CD then is the Triangle CBD the true Projection of the Question, with Allowance for the Current, in which the Angle BCD 29. 56. is the true Course made good, the Hypotenuse CD 81. 6. the Distance, the Leg CB 70. 7. is the difference of Latitude, and B. D. 40. 7. is the Departure, as may be found by Measuring them Geometrically,

Arithmetical

Arithmetical Calculation.

By Case the first of plain Sailing.

As Radius	90.0	10.0000
To the Distance	10.0	2.0000
So Sine Comp. Course	45.0	9.8494
To difference of Latitude	70.7	1.8494

The departure is also 70.7 equal to difference of Latitude, because the Course is South East, viz. at an Angle of 45 degrees.

But because the Current had set her 30 Miles W. in the same time, therefore subtract 30 from the departure found 70.7, there remains 40.7, the true departure with allowance for the Current.

Then you have the true difference of Latitude and Departure given to find Course and Distance, by Case the Sixth of plain Sailing.

As Difference of Latitude	70.7	1.8494
To Radius	90.0	10.0000
So true departure	40.7	1.6095
To Tangent of the Course	29.56	9.7601

Then for the Distance.

As Sign of the Course	29.56	9.6980
To Departure	40.7	1.6095
So is Radius	90.0	10.0000
To the distance made good	81.6	1.9115

Or the Distance may be found thus, by Case the fourth of oblique plain Triangles.

In the oblique Triangle $b c d$ there is given the side $b c$ 100 and the side $d c$ 30, and the Angle between them 45 degrees: Then by Case the Fourth of oblique plain Triangles.

the Sum of the Sides ——— 130 2.11394

the difference of the sides ——— 70 1.84509

the Tang of $\frac{1}{2}$ the Sum of the } 67.30.10.38277
unknown Angles

the Tang. of $\frac{1}{2}$ their Difference. 52.26.10.11392

Hence the Angle $b d c$ is 119 $\frac{56}{56}$, and the Angle d is 15 $\frac{4}{4}$.

Then for the Side $b d$, which is the true Distance made good.

Sine of $d b c$ ——— 15 $\frac{4}{4}$ Co. ar. 0.98513

the Side $d c$ ——— 30 ——— 1.47712

is the Sine of $b c d$ ——— 45 $^{\circ}$ ——— 9.84948

the side $b d$ 81.6 the Distance required 11.91173

But suppose the Current had set upon an oblique course, and not due East, West, North, or South, the operation had been more difficult: As for Example,

Arithmetical Calculation.

In the Triangle ASd right angled at S , you have
 the Hypotenuse Ad 30, and the Angle at A
 30 (because Ad is a N. N. W. Line) to find AS and
 by Case the first of right-angled plain Triangles.

Radius	90 00	10.00000
to the Hypotenuse Ad	30 —	1.47712
is the Sine of the Angle at A	67 30	9.96561
to the Leg Sd	27 7	11.44273

Radius	90 0	10.00000
to the Hypotenuse Ad	30 —	1.47712
is the Sine of the Angle at d	22 30	9.58284
to the Leg AS	11 5	11.05996

The Leg Sd 27 7 equal to qB , subtracted from
 the whole Difference of Latitude CB 70 7, leaves Cq
 the true Difference of Latitude 43 0; and the Leg S
 11 5, subtracted from the whole Departure 70 7,
 leaves 59 2, the true Departure: By which you may
 find the true Course and Distance by Case the sixth of
 plain Sailing.

Difference of Latitude	43 0	1.63346
to Radius	90 0	10.00000
is Departure	59 2	1.77232
to the Tang. of the Course	54 0	10.13886

Ans

As Sine Comp. Course SC ——— 54 0 — 9.7692
 To Difference of Latitude ——— 43 0 — 1.6334
 So is Radius ——— 90 0 — 10.0000

To the Distance ——— 73 2 — 1.8642

The true Course is 54 Deg. from the South Eastward
 or S. $E\frac{1}{4}$ East, and the Distance is 73
 Miles.

Case II. Course and Distance sail'd, and Course and Distance made good, given, to find the Course and Motion of the Current.

A Ship sails (by the Compass) S. by E. 36 Miles and then arrives at a Place which is known to bear from the Place sail'd from S. E. by S. 54 Miles, (having been deceived by an unknown Current) I demand which Way the Current sets, and how fast, supposing the Ship to sail by the Log 4 Miles an Hour.

Geometrical Construction.



In this, and all other Cases of Current, as well as plain Sailing Traverse, &c. draw the North and South Line AB , and set off the Course steer'd S. by E. and the Distance 36 Miles from A to C then set off also the Course and Distance made good 54 Miles S. E. by S. from A to D : Then because by the Course steer'd by the Compass, and Distance run by the Log, the ship should have been at C , but is found at D , therefore I am sure there is some Current hat

Questions concerning Currents. 337

Let me in the same Time from C to D, therefore draw the Line C D for the set of the Current, which measured will be found to be 25 Miles. And the Angle A C D accounted from the N. by W. Point (because the Line C A is a N. by W. Line) will be found to be 1 Point from the N. by W. Eastwards, viz. E. S. E. Deg. 9 Min. southerly, for the true Course of the Current by the Rule laid down in Traverse sailing Geometrical for laying down Courses by Distance of Points.

Arithmetical Calculation.

In the oblique Triangle A C D, you have given the side A C 36 Miles, and the side A D 54 Miles, and the Angle between them 2 Points, or $22^{\circ} 30'$ (being the Distance between S. by E. and S. E. by S.) to find the Angle A C D, and the side C D, by Case the Fourth of oblique plain Triangles.

Co. Ar.

As the Sum of the given sides — 90 — 8.04576

To their Difference — 18 — 1.25527

To Tang. of $\frac{1}{2}$ Sum of unknown Angles 78: 45: 10.70134

To Tang. of $\frac{1}{2}$ their Difference — 45. 9 10.00237

The half difference of the Angles — $45^{\circ} 9'$

Added to the half sum — 78 45

The sum is the Angle A C D — 123 54

which reduced to Points of the Compass, is 11 Points, Deg. 9 Min. and that accounted from N. by W. finds E. S. E. 0 deg. 9 min. southerly, for the true Course of the Current.

Then for the Side C. D. the Current's Race in that time.

Co. Ar.

As sine of the Angle A C D $123^{\circ} 54'$ — 0.08092

To the side A D — 54 — 1.73239

So is sine of the Angle C A D — $22^{\circ} 30'$ — 9.58283

To the side C D required — 25 — 1.39614

A a

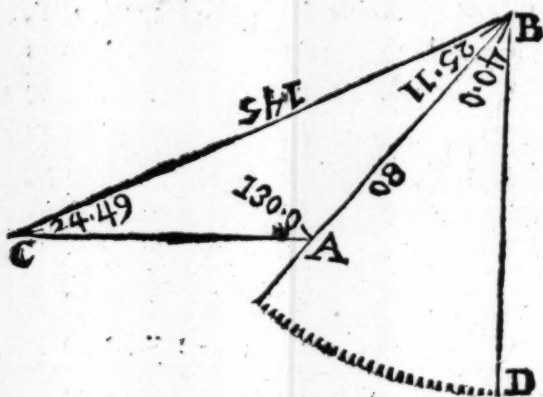
So

So that the Current set 25 Miles *E. S. E.* 9 min. *Southerly*, in the time that the Ship sail'd, by the Log, 36 Miles *S. by E.* and supposing the Ship to sail 4 Miles an Hour, she would sail 36 Miles in 9 Hours, in which time the Current set 25 Miles, therefore divide 25 by 9, the Quotient $2\frac{1}{2}$ Miles is the Hourly Motion of the Current.

Case III. Course and Distance made good by the Ship, and Course and Motion of the Current given to find the Course and Distance sail'd: Or, more properly thus, Having the Bearing and Distance, between two Ports or Islands, given, and having also the Course and Motion of a Current that lies between them given, to find what Course to steer by the Compass, or how much to Windward of your true Course to steer, that so the Compound Motion of the Ship may just set her to the desired Port.

There are two Islands *A* and *B*: The Course from *B* to *A* is *South* 40° Degrees, *Westerly* 80 Miles: The Current sets *East* $2\frac{1}{2}$ Miles an Hour, a ship sails 4 Miles an Hour, I demand what Course she must steer from *B* to *A*, and how far she must sail by the Log before she arrive at *A*, the Port desired.

Geometrical Construction.



Draw the *North* and *South* Line *BD*, and set off the Course and Distance from *B* to *A*: *South* 40° Degrees *West*, 80 Miles from *B* to *A*: Then because the Current sets *East*, draw the *East*

Questions concerning Currents.

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East and West Line AC at Pleasure, by the Rule liad down in Traverse sailing Geometrical, then is the side AB 80 Miles, and the Angle BAC $130^{\circ} 00'$ given; but you have no other side nor Angle given in the oblique Triangle ABC , but you have the Proportion of the two sides CA and CB , for CA represents the Motion of the Current $2\frac{1}{2}$ Miles an Hour, and CB represents the Motion of the Ship thro' the Water $4\frac{1}{2}$ Miles an Hour: Therefore find the Angle ABC by Case the Second of oblique plain Triangles.

As the side BC $4\frac{1}{2}$, or in Decimals	4.5	Co. Ar. 9.34679
To the Angle BAC ———	130.0 ———	9.88425
So the side AC $2\frac{1}{2}$, or ———	2.5 ———	0.39794
		—————
To the sine of the Angle ABC —	25.11 ———	9.62898

The Angle ABC is $25^{\circ} 11'$, therefore make the Angle ABC 25.11 , and draw the Line BC to cut A in C , and then is the Projection finished, and the Angle ABC $25 11$ added to the Angle ABD $40^{\circ} 00'$, the sum $65^{\circ} 11'$ from the South Westerly, or $W. S. W.$ almost $\frac{1}{4}$ Southerly, is the Course that the Ship must steer to gain the Port with Allowance for the Current.

Then for the side BC , the Distance sail'd by the Log, subtract the sum of the two Angles A and B $155^{\circ} 11'$ from $180^{\circ} 00'$, the Remainder $24^{\circ} 49'$ is the Angle ACB . Then——

As Sine of the Angle ACB	24.49	Co. Ar. 0.37705
To its opposite side BA ——	80——	1.90309
So sine of the Angle BAC ——	$130-0$ ——	9.88425
		—————
To the side opposite BC ——	146 ——	2.16439

The Distance sail'd by the Log is 146 Miles, and the Rate of Sailing is $4\frac{1}{2}$ Miles an Hour, therefore divide
A a 2 vide

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vide 146 by $4\frac{1}{2}$, the Quotient $32\frac{1}{3}$ is the Hours that the ship will be in sailing from B to A.

Now if you would prove the Work, multiply $32\frac{1}{3}$ the Hours that the ship is in sailing by $2\frac{1}{2}$, the Miles that the Current sets in one Hour, the Quotient $81\frac{1}{3}$ is the Miles that the Current sets in that Time represented by the side AC, which you will also find to be by the following Canon.

As Sine of B AC	— — —	130.0	Co. Ar	0.11575
To side opposite B C	— — —	146		2.16439
So sine of A B C	— — —	25.11		9.62891
To side opposite AC	— — —	81.1		1.90905

Note, It is necessary in this Case to know how fast the ship sails, for the faster she sails, the less she need lye to Windward of her true Course against the Current.

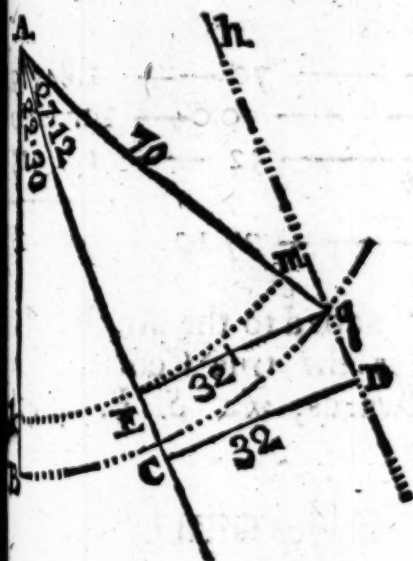
Case

Case IV, or Question IV.

There are other Varieties in sailing in a Current, some of which I shall instance for the Learner's Improvement and Diversion.

A Current sets 32 Miles a Day E. N. E. a Ship Sailing therein steers S. 8 E. by the Compass, and finds that in 24 Hours she is 70 Miles distant from the Place sail'd from; I demand upon what Point she hath made her Way good, and how far she hath sail'd by the Log?

Geometrical Construction.



Draw the N. and S. Line *AB*, and set off the ship's Course steer'd S. 8. E. 22. 30, and draw the Line *AC* continued; then any where upon that Line, as at *C*, draw an E. N. E. Line (as the Line *DC* by the Rule laid down in Traverse sailing Geometrical) to represent the Set of the Current, upon which set off 32 Miles,

the Current's Motion in 24 Hours, from *C* to *D*, then at the nearest Distance from *D* to the Line *AC* (which here happens to be the Length of the Line *CD*, because *CD* is perpendicular to *AC*) draw the Parallel *DE* then with 70 Miles (the Distance made good) in your Compasses, and one Foot in *A* describe the Arch *Bg* continued, and where it cuts the Parallel *DE* as in *g*, begin the Line *gE*, drawing it Parallel to the Line *DC*: Then is *Ag* 70 Miles the Dist. made

A 4 3

good,

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good, Eg 32 Miles, the Set of the Current $E. N. E$
The Line AE 62.3 Miles, the Distance sail'd by the
Log, and the Angle EAg $27^{\circ} 12'$ added to the An-
gle BAC $22^{\circ} - 30'$, the Sum $49^{\circ} - 42'$ is the Course
made good from the *South Eastward*, or the Arch k
measured on the Rumbs, gives $S. E. 4$ Deg. 42 Min
Easterly.

Arithmetical Calculation.

In the Triangle Aeg you have given the Distance
made good Ag 70 Miles, and the Motion of the
Current Eg 32 Miles, and the Angle Aeg (which
happens here to be a Right Angle) 90 deg. to find the
Angle EAg thus.

As side Ag —————	70 ———	1.8450
To Angle opposite Aeg ———	90.0 ———	10.0000
So side Eg —————	32 ———	1.5051
To Angle opposite EAg ———	27.12 ———	9.6600

The Angle EAg $27^{\circ} 12'$ added to the Angle BAC
 $22^{\circ} 30'$ the Sum $49^{\circ} - 42'$ is the true Course, made
good from the *South Eastwards*, viz. $S. E. 4^{\circ} 42'$
Easterly.

Then for the Side AE the Distance sail'd by the Log

As the Angle Aeg —————	$90^{\circ}.0'$ ———	10.0000
To Side opposite Ag —————	70 ———	1.8450
So the Angle AgE —————	62.48 ———	9.9491
To side opposite AE —————	62.3 ———	1.7941

The Course made good is SE $4^{\circ} 42'$ Easterly
and the Distance sail'd by the Log is 62.3 Miles.

And if you would prove the Work by Inverting

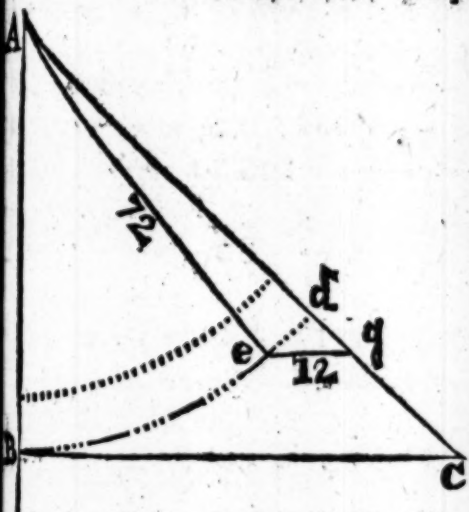
the Question, and proposing it in the first Case of Current Sailing thus.

A Ship sails S. S. E. 62.3 Miles in a Current that
E. N. E. 32 Miles, in the same time you will find
the Answer produces 70 Miles S. E. $4^{\circ} 42'$ Easterly,
for the Course and Distance made good.

Note, although in this Case the Triangle $A E g$ is Right Angled, because the Current's Race E. N. E. makes a Right Angle with the Ship's Course S. S. E. yet in any other Case it would have been an oblique Triangle; but the Rules both for Projection and Calculation would have been the same.

Question the Fifth, A Ship sails 72 Miles a Day by the Log, in a Current that sets East 12 Miles a Day, and then finds that she hath made her Way good South East, I demand what Course she steer'd by the Compass, and what distance she made good.

Geometrical Construction.



Draw AB , and with an Angle of 45 deg. the Course made good, draw the Line AC continu'd, then with 72 the Distance sail'd by the Log sweep the Arch Bd ; then any where upon the Line AB as at B , make an East and West Line be-

cause the Current sets East; then take 12 Miles in your
Compasses the Current's Motion, and set it Parallel to
BC, and so as that it may just extend from the Arch
Bd to the Line AC, as here from e to g, and draw
the Line eg and 'tis done — or if you think this
Method too mechanical for laying down the Line x e

A a 4

you

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you may do it thus: You fore-see that in the Triangle Aeg when laid down, there will be given the side e 72, and the Angle opposite to it 45° deg. and the side eg 12, to find the Angle eAg thus.

As side Ae ————— 72 Co. Ar. 8.1426
 To sine of Angle opposite Age — 45.0 — 9.8494
 So side eg ————— 12 — 1.0791

To sine of Angle opposite gAe — 6.46 — 9.0713
 which added to the Angle Age 45° deg. the Sum 51.46 subtracted from 180, leaves 128.14. the Angle Aeg , therefore having set off 72, from A , upon the line Ae from A to e , at e draw the Line eg , to make an Angle of 128.14 with the Line Ae , this Line carefully done will just contain 12 such Parts, where the Line Ae contains 72, by that time it is extended to cut the Line Ag .

Then for the side Ag the Distance made good.

As sine of eAg ————— 6.46 Co. Ar. 0.5286
 To side eg ————— 12 — 1.0791
 So sine of Aeg ————— 128.14 — 9.8951

To side Ag the Dist. made good-- 80 — 1.9029

Therefore for the Course steer'd, subtract the Angle eAg 6.46 from the whole Angle given Age 45° , the Remainder 38.14 is the Angle, eAe the Course steer'd and the side Ag found to be 80 is the Distance made good.

Note, In finding the sine of any Angle above 90 Degrees, you must subtract the Angle (whose sine required) from 180 deg. the sine of the Remainder is the sine of the Angle required, as in the Example above, where the sine of 128.14 is required, subtract 128.14 from 180, the Remainder $51^\circ 46'$ sought in the Table

Table of sines, the sine answering to it is 9.89514 which is also the sine of 128.14 which was required; the Reason of which is evident from the Diagram at the Beginning of this Book, in which if you account $128^{\circ}14'$ from k upon the Arch $k90S$, it will reach to the Point x , and the Perpendicular xz is equal to a Perpendicular let fall from $51^{\circ}46'$, as you may observe by the Degrees numbred from S upwards towards 90 , the same Degree and Minute which answers to $128\ 14$ if numbred from k , answers to $51\ 46$ if numbred from S . &c.

And thus much for plain Sailing in a Current; many more Questions might be invented from other Data's, but I would study Brevity, that the Book may not be too chargeable to the Buyer, supposing that by a right Understanding of these Rules the Ingenious will be able to project, and answer any other Case or Question in that kind; and as for Traverse Sailing in a Current, although I thought to have placed it in a Section or Chapter by it self, yet I find it altogether needless; for the Courses being first all reduced to one, by the Rules laid down in Traverse Sailing, the Operation for allowing for known Currents, or finding the Course and Motion of unknown Currents, is the very same with the Rules here laid down.

OF
TURNING
To Windward in a
CURRENT.

THIS may also be divided into several Cases, of which I shall speak in order; but that which is chiefly useful is where the Course and Motion of the Current is given, with the Course and Distance between the Place sail'd from, and the Place bound for, and from what Point the Wind blows, and how near the Wind the Ship will make her way good (for these four Things are commonly given or known) to find how long she must lye upon each Tack to gain her Port, supposing her Rate of running or Miles sail'd in an Hour by the Log, be also given or known.

Example,

fore find how many Hours the Ship is in Sailing from A to C by the Log; in order to which you must find the side AC by dividing the Isosceles Triangle ABC into two Right angled Triangles Adc and Bdc then in the Triangle Adc you have given the Leg Ad 45 (being half the whole Line AB which is 90) and the Angle dAc 72 d. consequently the Angle ACd 8°—1' to find the Hypotenuse AC by Case the fourth, of right Angled plain Triangles.

As sine of Ac	18°—0'	9.48998
To side opposite Ad	45	1.65228
So Radius Ad	90—0	10.00000
To Hypotenuse Ac	145 $\frac{1}{2}$	2.16.23

Hence Ac is 145 $\frac{1}{2}$ Leagues or 436 Miles, which divided by 4 the Miles sail'd in one Hour, the Quotient 109 is the Hours, in which the Ship sails from A to C ; but the Current setting South 2 Miles an Hour, 'tis plain that in 109 Hours it hath set South 218 Miles, or 72 $\frac{2}{3}$ Leagues; therefore draw the South Line cg , because while she sail'd by the Log from A to C , the Current hath set her from c to g ; therefore draw the Line Ag which shall represent the true compound Motion of the Ship or Course made good; but because she is to lye upon that Tack, but only till she be got half Way to the Port sail'd for, observe where the Line Ag cuts the Perpendicular dc as in e , and then is the Angle dAe 49°—37' the true Course made good by reason of the Current, and the Line Ae the true Distance sail'd upon the Star-board Tack, viz. 69.3 Leagues, and eB the Distance sail'd upon the Lar. Tack being also 69.3 Leag. But to know how far she will have sail'd by the Log, by that time that she will be at e by the Help of the Current, draw ek parallel to gc , this Parallel shall cut Ac and

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and Ag proportionably by *Euclid. Lib. 6 prop. 2 viz.*
 As Ag to Ac , so Ac to Al , hence Al measured
 will be found to be 35.5 Leagues, or 166.5 Miles
 Sail'd by the Log, which divided by four, the Miles
 Sail'd by the Log in one Hour, gives $41\frac{1}{2}$ Hours, the
 time to stand upon the Starboard Tack, and the same
 upon the Larboard, to fall in with the Island at
 B, &c.

Arithmetical Calculation.

In the oblique Triangle Acg , there is given the
 side Ac 436 Miles, and the side cg 218 Miles, and the
 Angle included Acg $108^{\circ}-0'$ to find the Angle
 $C Ag$, by Case the Fourth of oblique angled plain
 Triangles.

As Sum of the sides	—————	654	Co. Ar.	7.18443
To Diff. of the sides	—————	218		2.33845
So Tang. of $\frac{1}{2}$ sum of unkno. Ang.	—————	36.0		9.86126
To Tang. of $\frac{1}{2}$ their Difference	—————	13.37		9.38414

The half difference $13^{\circ} 37'$ subtracted from the half
 sum 36.0, rests $22^{\circ} 23'$ the Angle $C Ag$, which sub-
 tracted from the whole Angle $d AC$ $72^{\circ}-0'$ leaves
 the Angle $d Ae$ $49^{\circ}-37'$ the Course made good.

Then for the true Distance made good Ae : In the
 Triangle Ade you have given Ad 45 Leagues, and
 the Angle $d Ae$ $49^{\circ} 37'$, consequently the Angle Ae
 $40^{\circ}-23'$ to find Ae by Case the second of Right
 angled plain Triangles.

As Sine of Aed	—————	$40^{\circ}-23'$		9.81150
To side opposite Ad	—————	45		1.65221
So Radius	—————	90—00		10.00000
To Hypotenuse Ae	—————	69.3		1.84071

Then

Then for the Distance sail'd by the Log Ak (which by the Help of the Current she is carried to e)

In the Triangle Ake , you have given Ae 69.3, and you have given all the 3 Angles, viz. Ake equal to ACg $108^\circ - 0'$, and Aek equal to Agc equal to dAe $49^\circ - 37'$, and kAe $22^\circ - 23'$, equal to gAc , to find the side Ak by Case the first of oblique Angle plain Triangles.

As sine of Ake ————— $108^\circ - 0'$ Co. Ar. 0.0217

To side opposite Ae ————— 69.3 ————— 1.8407

So sine of Aek ————— 49.37 ————— 9.8818

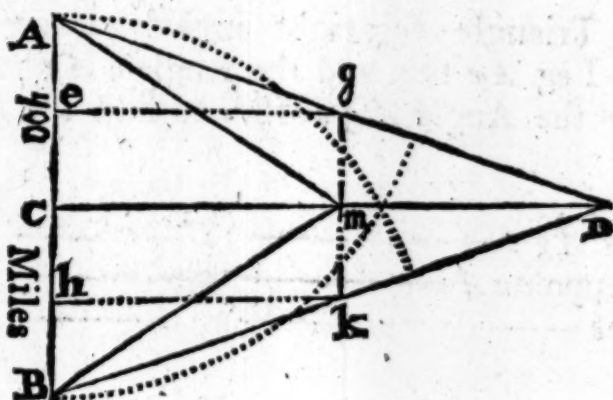
To side opposite Ak ————— 55.5 ————— 1.7443

The side Ak , the distance sail'd by the Log, is 55.5 Leagues, or 166.5 Miles, which divided by 4, the Miles sail'd in one Hour by the Log, the Quotient 41.2 is the Hours that she must lye upon the starboard Tack, in which Time she is carried by the Help of the Current from A to e , and then lying the same Time upon the larboard Tack, she will arrive at B , the desired Port; so that in 83 Hours, she performs the Voyage of 90 Leagues, although upon a Wind by the Help of the Current, which, had there been no Current, would have required 218 Hours, or 9 Days, and 2 Hours.

Question

Question the Second.

There are 2 Islands distant 400 Miles N. and S. from each other, suppose A and B, A being the Northernmost: A Ship at A intending for B, meets with the Wind at South, she gets her starboard Tacks Aboard, and makes her Way good through the Water, within 72 Degrees of the Wind, a Current at the same Time setting South 24 Miles a Day, she stood 4 Days upon each Tack, and then arrived at her Port at B: I demand my Course and Distance made good upon each Tack.



Geometrical Construction.

Draw the Line AB 400, and at an Angle of 72 Degrees, draw AD and BD to cut each other in D , and from that Intersection let fall the Perpendicular CD , which will fall upon the Middle of the Line AB , then is the Projection finished without Allowance for the Current; but because in that 4 Days that she had her starboard Tacks aboard, the Current had set her 96 Miles, set off 96 from C to e and h , and draw eg and hk parallel to CD , and where these Parallels cut the Lines AD and BD , as at g and k , draw the Line

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Line gk to cut the Perpendicular CD in m , and then to the Intersection at m , draw the Lines Am and Bm , for these Lines shall represent the true compound Motion of the ship, or Course and Distance made good, viz. The Angle CAm $57^{\circ}49'$ is the Course made good from the Meridian, and the Line Am equal to mB is the true Distance sail'd upon each Tack, viz. 372.6 Miles.

Arithmetical Calculation

In the Triangle Aeg right angled at e , you have given the Leg Ae 104, and the Angle eAg 72° . consequently the Angle Age 18° . to find the Hypotenuse Ag .

As sine of Age —————	$18^{\circ}-0'$ ———	9.48998
To side opposite Ae —————	104 ———	2.01703
So Radius —————	90.0 ———	10.00000
To Hypotenuse Ag —————		336.5 ——— 2.52705

Then in the oblique Triangle Agm , you have given the side Ag 336.5 and the side gm 96, because equal to Ce , and the Angle included Agm $108^{\circ}-0'$ to find the side Am .

As Sum of the sides —————	432.5 ———	7.36102
To difference of the sides —————	240.5 ———	2.38021
So 'Tang. $\frac{1}{2}$ sum of unkn. Angles ———	72.0 ———	10.48822
To Tang $\frac{1}{2}$ their difference ———		59.29 ——— 10.22945

Hence

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Hence the Angle $g A m$ is $14^{\circ} - 11'$, which subtracted from the whole Angle $C A D$ 72 , leaves the Course made good, $C A m$ $57^{\circ} - 49'$. Then for the Distance made good,

As sine of $G A m$ —————	$14^{\circ} 11'$ —	0.61079
To side opposite $g m$ —————	96 —	1.98227
So sine of $A g m$ —————	$108 - 0$ —	9.97820
To side opposite $A m$ —————	372.6 —	2.57126

The Distance made good upon each Tack is 372.6 Miles; the Distance sail'd by the Log upon each Tack is $A g$ and $B k$ 336.5 , the Course made good $57^{\circ} 49'$ from the Meridian.

B b

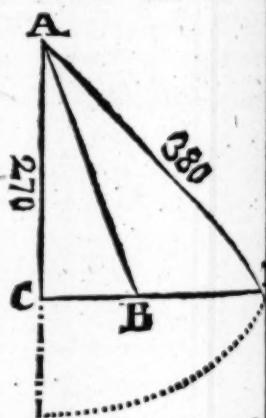
Question

Question the Sixth.

A Master of a Ship having taken a Freight from an Island at *A*, to another Island at *B*, and having his Son aboard along with him to gain Experience, he enquires of his Father, whether there was not a Current setting upon some Point between the two Islands; his Father refusing to tell him, bid him observe well the Dead Reckoning Outward-bound, and also Home; and see if he could not, by comparing them, find the true Course and Motion of the Current: Whereupon the Captain, who knew very well what Way the Current set, and how the Islands bore upon each other, caused them to steer away South, and in Running 270 Miles upon that Course, they arrived at *B*, and having done his Business there, they steered North West, and Running 380 Miles upon that Course, they arrived at *A*. Now I demand, How the Islands bear from each other, and how far distant; also which way the Current sets, and how fast, supposing the Ship sail'd always at the Rate of five Miles an Hour by the Log.

Geometrical Construction.

Draw the North and South Line *AC* 270 Miles, the first Course and Distance; then because her Course home was N. W. to *A*, draw the Line *AD* at an Angle of 45 deg. from *A* to *C* (because if *DA* be North West, *AD* must be South East, and consequently make an Angle of 45 deg with the Line *AC*) and set off 380 from *A* to *D*, and draw the Line *CD* which represents the Motion of the Current during the Ship's Sailing from *A* to *C* and from *D* to *A*; for finding



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finding of which you have given the side AC 270, and the side AD 380, and the contain'd Angle 45 deg. to find the Angle ACD by Case the fourth, of Oblique plain Triangles.

As Sum of the sides ——— 650. Co. Ar. 7.18708
 To Difference of the sides ——— 110. ——— 2.04139
 To Tang. of $\frac{1}{2}$ Sum of unkn. Ang. 67.30 ——— 10.38277
 To Tang. of $\frac{1}{2}$ their difference 22.13 ——— 9.61124

The half Sum added to the half Difference, makes the bigger Angle ACD 89.43.

Then for the side CD

Co. Ar.
 As sine of ACD ——— 89.43 ——— 0.00 01
 To side opposite AD ——— 380 ——— 2.57978
 So sine of CAD ——— 45.0 ——— 9.84948
 To side opposite CD ——— 268.7. ——— 2.42927

The side CD 268.7 Miles is the Current's Race during the whole Voyage: Now to find the Bearing and Distance of the Islands, we see that in the whole Voyage, out and home the Ship runs 650 Miles, which at 5 Miles an Hour, requires 130 Hours, in which time the Current sets 268.7 Miles, but her Voyage outward being but 270 Miles, which at 5 Miles an Hour requires but 54 Hours, therefore say by the Rule of Three, if in 130 Hours the Current sets 268.7 Miles, how far will it set in 54 Hours?

$$\begin{array}{r} 268.7 \\ 54 \\ \hline 10748 \\ 13435 \\ \hline 14509.8 \end{array}$$

$$\begin{array}{r|l} 11 & 9.8 \\ 1450 & (110\frac{1}{11} \text{ fere} \\ 1333 & 0 \\ 11 & \end{array}$$

B b 2

The

The Current's Race while the Ship sails by the Log from *A* to *C* is $110\frac{1}{2}$ almost, but for Ease of working we will call it 110.8, which let upon the Line *CD* from *C* to *B*, and draw *AB* which represents the true Course and Distance between the two Islands, for the finding of which by Calculation, you have given, in the Triangle *ABC*, the side *AC* 270, and the side *CB* 110.8, and the contained Angle *ACB* 89.43 , to find the Angle *CAB*, by Case the Fourth, of Oblique plain Triangles.

As Sum of sides	380.8	Co. An
To Difference of the sides	159.2	7.4193
So Tang. of $\frac{1}{2}$ Sum unknown Angles	45.8	2.2019
To Tang. of $\frac{1}{2}$ their Difference	22.47	10.0020
		9.6232

Hence the Angle *CAB* is $22^{\circ} 21'$, the true Course from *A* to *B* South Easterly, which is S. S. E. 9 min Southerly.

Then for the side *AB* the true Distance between the Islands.

As sine of <i>CAB</i>	22.21	Co. An
To side opposite <i>CB</i>	110.8	0.4192
So sine of <i>ACB</i>	89.43	2.4454
To side opposite <i>AB</i>	291.4	9.9999
		2.4644

The true Distance between the two Islands is 291.4 Miles.

The Course of the Current is the Angle *ACD* found by the first Operation $89^{\circ}.43'$ from the North Easterly which is East 17 Minutes Northerly, and as for the Rate or Motion of the Current's running, it is found

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found by dividing the whole Race of the Current 268.7, by the whole Number of Hours that the Ship was under Sail 130, the Quotient is the Miles that the Current sets in one Hour, as appears by the Operation.

$$\begin{array}{r} 00 \\ 268.7 \overline{) 1300} \end{array} \begin{array}{l} 2 \\ 1300 \end{array}$$

Hence in answer to what was demanded, the Course from *A* to *B* is S. S. E. 0 d. — 9 m. Southerly — The Distance 291.4 Miles, the Course of the Current East 0 d. 17 m. Northerly, and its Rate or Motion 2 $\frac{1}{3}$ Miles an Hour.

Now if you would prove the Truth of the Operation you may easily do it, by Inverting the Question, and Stating it in the first Case of Current Sailing thus.

A Ship sails South 5 Miles an Hour in a Current, that sets East 17 min. Northerly 2 $\frac{1}{3}$ Miles an Hour, demand the Course and Distance made good, and you will find it will produce S. S. E. 9 min. Southerly for the Course, and 291.4 Miles for the Distance; but shall leave the Operation for the Reader's Practice.



Pleasant and useful QUESTIONS

I Thought to have added other Varieties of Question concerning Currents, but this being but an Appendix to a small Treatise, I fear if I should proceed, should exceed my intended Bounds, and therefore shall add no more, supposing that by what is laid down the Ingenious Student may easily Learn to Project and Answer any other necessary Question in that kind: I shall now proceed according to my Promise to Insert some other pleasant and useful Questions for the Reader's Improvement and Diversion.

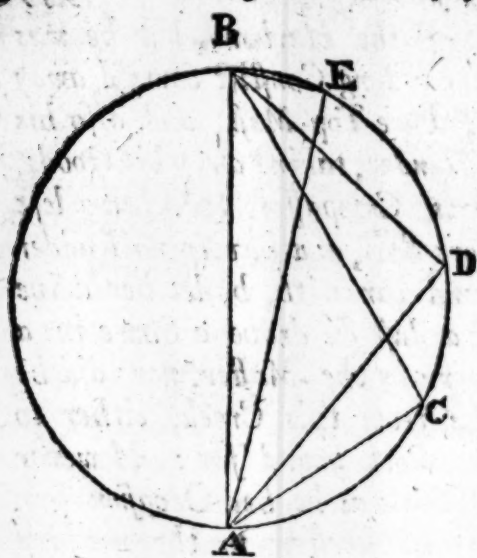
Question the First.

There is a round Sea or Lake of an unknown Diameter upon which the Wind is observ'd to blow always one Way but upon what Point of the Compass is unknown; upon the Coast hereof are two Ports A and B, Diametrically opposite to each other, so situate that the Trade Wind blowing there will be some where upon the Larboard Quarter, during their Sailing from A to B, but how many Points abaft the Beam is unknown, the Course and Distance between the two Ports is also unknown, — A Ship at A intending

for B, was no sooner got out of the Harbour, but he was assaulted by Pyrates, who after a long Conflict carry'd away his Main-Mast, Mizzen-Mast, Fore-Top-Mast, and also his Rudder, and came aboard to Plunder, taking away his Goods, his Books, Instruments, Charts, Compasses, &c. being left in this Distress he sets his Fore-Sail, and having no Rudder nor any more Sail to command her with, he let her drive Right before the Wind, 'till at last she drove a Shore in a little Creek, altogether unknown by the Master, nor did he know the Course or Distance from this Creek, either to the Port sail'd from, or to the Port bound for: However there he got such Masts and Sails as he had Occasion for, with a Rudder, and all that was Necessary to the working of the Ship, but could get no Books, Charts, Instruments, or Compass: I demand what Means he must use to guide himself to the Port at B.

Answer.

Although at first sight this Question seems impossible to be answer'd from what is given, yet with a little Consideration it is very easy; the Solution of it is grounded altogether upon the Thirty first Proposition of the Third Book of *Euclid*, where it is prov'd, that an Angle in a Semicircle is a Right Angle, &c. Now the two Ports *A* and *B* being propos'd opposite to each other, or in a Semicircle, it will necessarily follow that to what Place soever the Ship was blown from *A*, right before the Wind, and put a Shore, the same Wind upon the Beam would carry her to the Port at *B*, as appears by the Figure annexed.



The Angles ACB and ADB and AEB are all right Angles by the Proposition above-named; and therefore if from A the Ship is blown before the Wind to C , 'tis plain that the same Wind continuing, (as is here supposed) the Wind must needs be upon the Beam from C to B , because ACB is a just

Square, or right Angle,

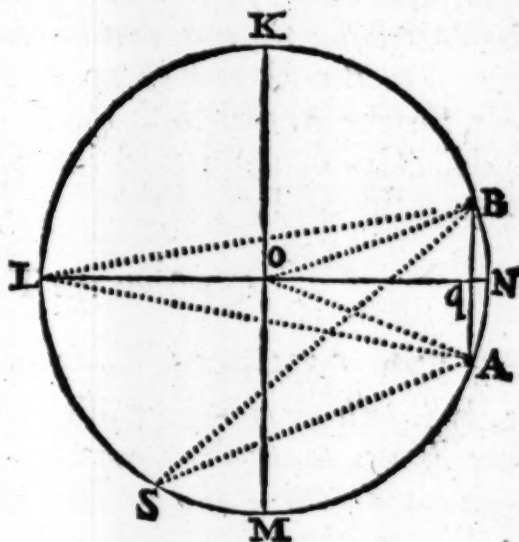
Or, Suppose the Wind blow from A to D , and the Ship driven before the Wind is blown ashore at D , it is plain that (the Angle ADB being a right Angle) the same Wind must be upon the Beam from D to B — and for the same Reason, if blown before the Wind from A to E , the Wind will be upon the Beam from E to B : See the Demonstration in the Book it self.

Question

Question the Second.

There is a round Lake, whose Diameter is 360 Miles, upon the Coast of which lye 2 Ports, A and B, whose nearest Distance in a straight Line is 120 Miles, but their Bearing or Situation is not known: A Ship at A sails away West a certain Distance, and then arrives at a nother unknown Port at C, whose Bearing and Distance both from A and B are unknown, and at the Port at C he takes in Goods for B, I demand what Course he must steer to find the Port at B.

First, Draw the Circle $KLMN$ to represent the Lake, whose Diameter KM or LN is 360 Miles, then assume any Point in the Circumference of the Circle, as at A to represent the Port at A ; then with 120 in your Compasses, the Distance of the Ports



in a straight Line, and one Foot in A , the other will reach to B , bisect the Arch AB at N , and thro' N and the Center o , draw the Diameter NoK , and at right Angles to it the Diameter KM , and draw the Line AB , then is the Line AqB the Chord of the Arch ANB and Bq is the Sine of BN to Radius Ko 180. Therefore,

As $K o$ —————	180 ———	2.25527
To Radius —————	90 00 ———	10.00000
So $B q$ equal to $\frac{1}{2} B q A$) ———	60 ———	1.77815
To Sine of the Angle $B o q$ ———	19.28 ———	9.52288
		The

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The Angle $B o q$ 19 28 doubled is 38 56, the whole Angle $B o A$ (because the Angles $B o q$ and $q o A$ are equal): Now suppose a Ship at A sails *West* to an unknown Port at L , I have already proved the Angle $A O B$ to be 38.56, and therefore the Angle $A L B$ is 19.28, because an Angle at the Center of a Circle is double to an Angle at the Circumference, by *Eucl. Lib. 3. prop. 20*; and therefore if from A to L be *West*, 'tis plain that from L to B is *East* 19 Deg. 28 Min. Northerly, and that is his Course from L to B .

Or for Variety, if you suppose the Port at S to be the Port sail'd to, and that from A to S is *West*, then from S to B will be *West* 19 Deg. 28 M. *North* as before, for the Angles $A L B$ and $A S B$ are equal, as is sufficiently demonstrated in *Euclid's Elements* in the forementioned Proposition.

Question the Third.

A Fleet of Ships with four Men-of-War, with Wind at W. by S. sails away S. E. 3 Miles an Hour, till Hearing of some Pyrates to the Northward from them, the Commadore sends out a Man-of-War a Cruising, who sails due North 7 Miles an Hour, for the Space of 11 Hours, and finding the Pyrate, he (after an Hour's Conflict) took him, the Fleet all the while Sailing S. E. 3 Miles an Hour. Now I demand what Course the Man-of-War and the Pyrate must steer, that they may just fall in with the Fleet, without Altering their Course, suppose they sail 7 Miles an Hour.

Geometrical Construction.

First draw the *North and South Line* $C A$ continued to B , then from A (the Place where the Fleet was when they heard of the Pyrates) set off the *S. E. Line*; $A E$; then because the Cruising Man-of-War sail'd 7 Miles

Miles an Hour North, for 11 Hours, viz. 77 Miles: Set off 77 Miles from *A* to *B* also, because the Commadore sail'd 3 Miles an Hour the 11 Hours that the Man-of-War was in Chase, and the one Hour that he was engaged, in all 12 Hours, which at 3 Miles an Hour is 36 Miles *S. E.* which set from *A* to *D*, then is the Commadore at *D*, and the Cruiser at *B*, when the Cruiser sets sail after the Commadore: Now because the Line *AE* is South East, or 45 Deg. the Angle *BAD* is 135 Deg. the Side *AB* is 77, and the Side *AD* 36, to find the other Angles by Case the Fourth of oblique plain Triangles.

	Co. Ar.	B
As Sum of Sides	113 —	7.94693
To Diff. of Sides	41 —	1.61278
So $T. \frac{1}{2}$ Sum unk. An.	22.30 —	9.61722
To Tang. $\frac{1}{2}$ Diff.	8.33 —	9.17693

Hence the Angle *ABD* is 13.57, *A* and the Angle *ADB* is 31.3, to find the Side *BD* by Case the Second of oblique plain Triangles.

	Co. Ar.	
As <i>S. ADB</i>	31.3 —	0.28754
To Side <i>AB</i>	77 —	1.88649
So <i>S. AAD</i>	135.0 —	9.84948
To Side <i>BD</i>	105.5 —	2.02351

Also the Angle *ADB* being 31.3, the Angle *BDE* must be 148.57, and although the Sides *BE* and *DE* be not given, yet their Proportion to each other is given, viz. As 7 to 3, so *DE* to *BE*, therefore,

As



			Co. Ar.
As Side BE	_____	7	9.15491
To Sine of Angle opposite BDE	148.57	—	9.71247
So Side DE	_____	3	0.47712
To Angle opposite DBE	_____	12.46	9.34450

The Angle BDE being 148.57, and DBE 12.46, DEB must consequently be 18.17, then you have given the Angles BED and BDE , and the Side BD to find the Side BE , the Distance sail'd by the Cruiser before he met with the Fleet.

			Co. Ar.
As Sine of DEB	_____	18.17	0.50347
To Side opposite BD	_____	105.5	2.02351
So Sine of BDE	_____	148.57	9.71247
To Side opposite BE	_____	173.6	2.23945

The whole Angle ABE 26.43 is the Course from the South Eastward, or S. S. E. 4d. 13m. Easterly the Cruiser must sail to fall in with the Fleet, and his Distance 173.6 Miles before he comes in with them, which, at 7 Miles an Hour, would require almost 25 Hours, in which Time he will fall in with the Fleet.

A

New and exact Method

For finding the Longitude in any Place of the World, any Day at Noon, when the Sun can be seen without any Regard to, or Dependance upon the Dead Reckoning.

THE often attempted, but never accomplish'd Work of finding the Longitude by an Observation is a Difficulty, which hath hitherto prov'd Insuperable, even to the best Mathematicians in *England*, and elsewhere, although since the late Act of Parliament, many have exerted their utmost Industry for the attaining of that End, some of whom have been so far from compleating their Intended Design, that they have, on the other Hand, rather rendred themselves and their Works ridiculous, by Publishing such Improper and Improbable Methods, as a certain Artist, (if he deserves that Name) by certain fixed Stars, chosen for each Time of the Year, &c.

Whereas it is evident, that any fixed Star shall come upon the Meridian of any Place, at (near) the same Hour of the Day, that the same Star shall come upon the Meridian of *London*, although not at the same Instant

Instant of Time, but sooner or later, 3, 4, 5, or 6 Hours &c. according as the Place is more or less distant East or West from the Meridian of *London*: but if there be that Difference in Hours as to the time of a Star's coming upon these two different Meridians, there is also the same Difference in Hours between the time of the Day or Night at *London*, and that under that Meridian; a South Sun in both Places making 12 a Clock; and 'tis very evident that at the same time of the Day or Night, that the Star comes upon the Meridian of *London*, it shall be the same time of the Day or Night under any other Meridian, when the Star comes upon that Meridian, excepting so much as the Sun's right Ascension is increased in the time of the Sun's passing from one Meridian to the other, which will cause the Star to come so much sooner upon a Westerly Meridian then upon an Easterly. But this being so little, being but about 4 Minutes of time in 24 Hours, or 360 Degrees of Longitude, and but 1 Minute of time in 90 Degrees, it is Imperceptible, and yet (that small Allowance excepted) there is no difference between the Hour of any fixed Star's coming to the Meridian of *London*, and the Hour of the same Star's coming upon any other Meridian, because the Sun's Motion makes the Hours of the Day, and the Star must needs come upon the Meridian the same Quantity of time after the Sun in both places. Indeed if we could certainly know what time of the day or night it is at *London*, when the Sun or any known Star is upon the Meridian of any other distant Place, the Longitude might be easily and exactly found; in order to which let the Master provide a good Glass, which may run exactly 24 Hours, or rather a good Watch that hath been observ'd ashore, to keep a true and equal Motion, this Watch set to the time of the Day when you depart from any known Meridian, and kept going, will shew the Difference of Longitude, that you

you make whether East or West; for Example, if you sail Westwards, observe just when the Sun is upon the Meridian, and see what Hour and Minute it is by your Watch, (which if you sail Westward it will be past 12) for those Hours and Minutes which the Watch is past 12, when the Sun is upon the Meridian reduced to Degrees and Minutes of the Equator, allowing 15 Degrees to one Hour, and one Degree to every 4 Minutes of time, and 15 Minutes of Longitude to one Minute of time, shall shew the true Difference of Longitude.

Note, If you Sail Eastward, your Watch will want something of 12 a Clock, when the Sun is upon the Meridian, because then you meet the Sun, and have him upon your Meridian before he comes upon the Meridian of *London*; in this Case observe how much your Watch wants of 12 a Clock, and that reduc'd as before gives your Difference of Longitude *Easterly*: This in general is the Method that I shall recommend to the World for this End.

But I know it will be presently objected, that this is no new Thing, nor is it Practicable at Sea; for some that have attempted to keep some Account of their Longitude this way, have found themselves in an Error, not finding the Difference between the Watch, and the Sun when reduc'd as above, to give the Difference of Longitude, which they were (for some Reasons) pretty confident they had made, and this Error they impute to the Watch, and hence have inferred, That a Watch will not go so truly and regularly at Sea as on Shore, by reason of the Salt Moist Air that impedes its Motion or makes it uncertain, according to the Variableness of the Weather, and thereby renders this Method for finding the Longitude impracticable.

I answer, I do not believe at all that this Error is to be Imputed to the Watch if carefully kept, which you may easily do, if you provide a little Square or round Box about 4 or 5 Inches Broad, and have it fill'd with fine Cotton, taking part of the Cotton out and putting the Watch towards the Middle of the Box upon the Cotton you leave in the Box, and put the rest that you took out upon the Watch, and shut the Box, keeping it in some dry Place, as in your Cabbin, or upon some Shelf near your Bed: I question not but a good Watch so kept would go as true at Sea as ashore.

But I suppose the Errour which hath been observ'd and which hath caused any to desist from making any Attempts to find the Longitude this way, is for want of a Right understanding of the Equation of time, without which it is impossible to keep a good Watch right, or to suppose her to be so either at Sea or ashore; for a good Watch, (or Clock) divides the time equally, but the Sun by Reason of some Inequalities in his Motion divides the time unequally; so that if the Sun and a true Watch be set together at some times in the Year, yet the Watch will at other times differ 10, 12, yea sometimes 16 Minutes from the time given by the Sun, and yet no Fault in the Watch, and therefore it is very evident that if for finding the Longitude you only observe the time of the Day given by the Watch, without regarding this Equation, especially when the Equation is great, as 15 or 16 Minutes, you will be so much wrong in your Account of Longitude, as that 15 or 16 Minutes reduc'd to the Equator amounts to, *viz.* about 4 Degrees of Longitude, which is an intolerable Errour, and might be prevented by allowing for the Equation of time.

For further Illustration hereof, Suppose you set your Watch with the Sun the sixth Day of *June*, then the Equation

Equation is nothing, being in *London* at the same time, and continuing there till the 23d Day of *October*, you will find your Watch to be got 16 Min. behind the Sun, from hence (if you do not know to the contrary) you might by the Foregoing Rule conclude that you had altered your Lon: 4 D. Easterly, but if to the time given by the Watch, you add the Equation 16 Min. the Sum is the true time of the Day by the Sun, and proving you to be in the same Meridian that you were under, when you set your Watch to the Sun, the difference in time and consequently the difference of Longitude being nothing at all.

C c

A Table

A Table of the Equation of Time.

	Jan.		Feb.		March		April.		May.		June.	
	M. S.		M. S.		M. S.		M. S.		M. S.		M. S.	
1	9	4	14	48	10	4	0	45	4	10	1	2
2	9	26	14	46	9	47	0	28	4	11	0	50
3	9	48	14	44	9	30	0	12	4	12	0	37
4	10	10	14	41	9	13	0	3	4	13	0	25
5	10	31	14	37	8	55	0	18	4	12	0	13
6	10	50	14	32	8	37	0	33	4	11	0	0
7	11	9	14	27	8	19	0	48	4	10	0	13
8	11	27	14	21	8	1	1	2	4	8	0	26
9	11	45	14	15	7	43	1	16	4	6	0	39
10	12	2	14	7	7	25	1	28	4	3	0	52
11	12	18	13	59	7	6	1	41	4	0	1	4
12	12	34	13	50	6	47	1	54	3	56	1	17
13	12	47	13	41	6	28	2	6	3	51	1	30
14	13	2	13	31	6	10	2	16	3	46	1	43
15	13	15	13	21	5	51	2	27	3	40	1	56
16	13	27	13	10	5	32	2	38	3	34	2	8
17	13	38	12	59	5	14	2	48	3	28	2	20
18	13	48	12	47	4	55	2	57	3	21	2	32
19	13	58	12	35	4	36	3	6	3	13	2	44
20	14	7	12	22	4	17	3	14	3	5	2	56
21	14	15	12	8	3	53	3	22	2	56	3	7
22	14	22	11	54	3	40	3	30	2	48	3	19
23	14	23	11	40	3	22	3	37	2	39	3	30
24	14	34	11	24	3	3	3	43	2	29	3	41
25	14	38	11	9	2	45	3	49	2	19	3	51
26	14	42	10	54	2	26	3	53	2	9	4	1
27	14	45	10	38	2	9	3	57	1	59	4	11
28	14	47	10	21	1	51	4	1	1	48	4	21
29	14	48			1	34	4	4	1	37	4	29
30	14	49			1	17	4	7	1	25	4	37
31	14	49			1	1			1	14		

A Table of the Equation of Time.

	July. M. S.	Aug. M. S.	Sept. M. S.	Octob. M. S.	Nov. M. S.	Dec. M. S.
1	4 45	4 28	3 53	13 18	15 21	5 35
2	4 53	4 18	4 14	13 22	15 13	5 6
3	5 0	4 8	4 34	13 46	15 3	4 38
4	5 7	3 57	4 55	13 59	14 53	4 9
5	5 13	3 47	5 15	14 11	14 41	3 40
6	5 18	3 37	5 36	14 23	14 29	2 10
7	5 24	3 27	5 56	14 34	14 17	2 40
8	5 29	3 8	6 17	14 44	14 3	2 10
9	5 33	2 55	6 38	14 54	13 49	1 40
10	5 36	2 42	6 58	15 4	13 34	1 11
11	5 39	2 27	7 19	15 13	13 17	0 41
12	5 42	2 13	7 39	15 22	13 0	0 11
13	5 44	1 58	7 59	15 28	12 43	0 19
14	5 45	1 42	8 19	15 34	12 24	0 49
15	5 46	1 26	8 38	15 40	12 5	1 19
16	5 46	1 9	8 58	15 45	11 45	1 49
17	5 45	0 52	9 18	15 50	11 25	2 18
18	5 44	0 35	9 37	15 53	11 4	2 47
19	5 42	0 17	9 57	15 56	10 42	3 16
20	5 40	0 1	10 16	15 58	10 20	3 45
21	5 38	0 18	10 34	15 59	9 56	4 14
22	5 34	0 36	10 52	16 1	9 32	4 42
23	5 30	0 55	11 10	16 0	9 8	5 9
24	5 26	1 14	11 28	15 59	8 43	5 36
25	5 20	1 34	11 45	15 57	8 17	6 4
26	5 14	1 53	12 2	15 54	7 51	6 30
27	5 8	2 12	12 18	15 51	7 25	6 57
28	5 2	2 32	12 33	15 47	6 59	7 24
29	4 52	2 52	12 49	15 41	6 32	7 48
30	4 46	3 13	13 4	15 35	6 3	8 12
31	4 37	3 33		15 29		8 37

C c 2

This

This Equation of time is caused by an Inequality of the Sun's Motion from West to East, according to the Succession of Signs; for the Swifter that the Sun is in his Annual Motion from West to East, the Slower he must be in his Diurnal Motion from East to West, as is plain by the Figure in the Margin.



Suppose the Wheel *ABCDEF* to move round upon the Center *G* once in 24 Hours, according to the Order of the Letters *A B C D E F* and in the same Quantity of time, viz. 23 Hours, a Snail Creeps the contrary way, from *F* to *A*; now although

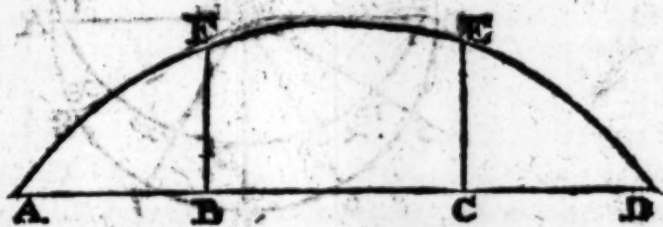
the Point *A* is come to the Place where it was, having gone once about, yet the Snail wants the Space *F* of a whole Revolution, and will not be got to the Top where *A* is, 'till *A* be got so far as the Point *Q*, which will be about another Hour, and if the Snail be mov'd yet faster, so that in 23 Hours she had gone from *A* to *E*, she would have been yet so much longer in arriving at the Top: viz. About 25 Hours, from hence it is plain, that the Faster the Snail Creeps from *A* towards *F*, *E*, &c. The longer she is in coming to the Top of the Wheel moving the Contrary way, and consequently the Faster the Sun Moves from West to East in his Annual Motion according to the Succession of Signs, the longer he is in making one Diurnal Revolution; and although the Sun's Revolution from the Meridian to the same Meridian again always Determines the 24 Hours, yet it is plain, from hence that every 24 hours by the Sun is not exactly

same equal Space of time, which in Process of time makes a small Difference between the Sun and a good Watch, and is the occasion of the aforesaid Equation of time.

This Inequality of the Sun's Motion proceeds from Twofold Cause.

The first Cause is, the Obliquity of the Ecliptick, making an Angle with the Equator of $23^{\circ} - 30'$ or thereabouts; now the Ecliptick being properly an Oblique Circle, the Poles of the Equator, and not of the Ecliptick, being the Poles of the World, and the Center of all Diurnal Motion, the Right Ascension of the Sun must be accounted upon the Equator: and hence it is manifest, that although the Motion of the Sun in the Ecliptick were always equal, yet his Motion from West to East, or his right Ascension accounted upon the Equator, could not be so much, Increase so fast in *Aries* and *Libra*, where the Ecliptick makes an Angle of $23^{\circ} 30'$ with the Equator, as in *Cancer* and *Capricorn*, where the Sun's way in the Ecliptick is Parallel to the Equator.

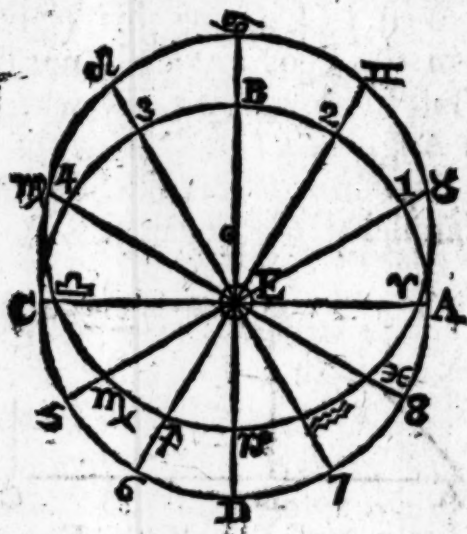
For Illustration of that hath been said, suppose the



Line *A B C D* to represent half the Equator, and the Arch *A F E D*, to represent half of the Ecliptick, now although the Segments *A F* and *F E* and *E D* are equal, yet Perpendiculars let fall from the Points *F* and *E* upon the Line *A B C D*, at the Points *B* and *C* do not divide that Line into three equal Parts, from whence it is plain that the Sun's right Ascension *D C* is not so much Increased by his Running from *D* to *E* as so great an Obliquity to the Equator, as the Sun's

Right Ascension CB is in his Running from E to I where his Motion is almost Parallel to the Equator and then if his Motion from West to East be Swifter in the Tropicks, for Reasons now given, his Diurnal Motion must be Slower by the first Demonstration.

But a 2d Cause of this Inequality is occasioned by the Eccentricity of the Sun's Orb, (whether we allow the Sun or Earth the Motion it matters not, but in this we Case shall Impute the Motion to the Sun) which moves in his Orb sometimes nearer, sometimes farther off from the Earth, by which Means although the Sun's Motion in his Orb were always equal, yet it would appear to us to be sometimes Swifter than at other times from West to East, and consequently Slower in his Diurnal Motion, as you see Demonstrated in the following Figure.



In this Diagram suppose the Earth at the Center about which is Describ'd the Circle $ABCD$, which is equally divided into 12 Parts, at the Points A , B , C , D , &c. representing the 12 Signs which in themselves are equally divided. Now if the Sun did move in the Circle $ABCD$, which is equally distant from the Earth its Center at E , his Motion would

be Regular and certain, but the Earth being not the exact Center of the Sun's Orb, makes the Division of the Signs, although equal in themselves, to appear unequal to us: for the Illustration of which, Suppose the Sun to move in the uppermost Circle, marked γ & δ &c. whose Center is at the Mark $\odot$, and suppose the Earth at the Center of the other Circle near the Mark E ; now although with respect to the Center E , the Divisions or Lines drawn from thence are equally Distant, yet these Lines continued to the uppermost Circle in which the Sun is suppos'd to move, the Divisions upon that Circle are very unequal, and therefore although the Sun's proper simple Motion should be always equal, yet it is very plain that the sun in Capricorn when nearest the Earth, shall appear to us to run more swift, than when in Cancer, in his Aphe- lion or greatest Distance from the Earth, by Reason of the smaller Division of the signs, not that they are really so, but appear so to us, because of the Nearness of the Sun's Orb to the Earth, as you see the Points γ and $\simeq$ are Diametrically opposite to each other, supposing the Eye at the Center E , where the Earth is suppos'd to be, and the far greater Part of the Circle is above the Line $\gamma \simeq$ which yet contains but six Signs, and the far lesser part is below that Line which contains also six Signs, and yet the signs equally di- vided upon that Circle, whereof the Earth is suppos'd to be the Center.

Note, I am not here undertaking to determine whe- ther the Sun or Earth be the Center of the World, or whether the Orbs of the Planets be Circular or Ellip- tical; for which way so ever it be, this Demonstration serves to Illustrate what I am now upon, as to the Equation of Time; and to let the Reader see the Rea- sons thereof, which is all that is expected from this Diagram.

Now the Occasion of this Equation being Twofold,

as is proved, it is plain, that when both the Inequalities tend one Way, it alters the Equation faster, as about the middle of *December*, when the Sun is nearest the Earth, he appears to move faster from *West* to *East* by the last Demonstration; and also Running then almost parallel to the Equator, his Motion, according to the succession of Signs, must be swift, by the second Demonstration; and therefore his Diurnal Motion or Revolution from Noon to Noon, must require more Time, by the first Demonstration, and consequently the Watches must now go faster than the Sun; but in *June*, although that Part of the Ecliptick in which he is then, lies nearly parallel to the Equator, as in *December*, thereby Accelerating his *Easterly* Motion, to our Appearance; yet his Distance from the Earth being then in *Aphelion*, helps to Retard it, so that the Motion of the Equation is not then so evident.

From this Inequality, as grounded upon these Two Occasions, are the foregoing Tables of Equation of Time calculated, which will serve for many Years without any sensible Alteration. Their Use is so plain that every Body may understand it; for find the Month at the Top of the Leaf, and the Day at the Left Hand, and in the common Angle of Meeting you have the Equation in Minutes and Seconds, whether it be too Fast or too Slow, as the Title [Watch Too Fast] or [Watch Too Slow] Directs.

And now for the Application hereof to the finding the Longitude, when you set Sail observe in your Table of Equation of Time, how much the Watch is too Fast or too Slow, and set your Watch to it, and not exactly to the Time of the Day, unless it be when the Equation is nothing. As for Example, Suppose I am bound upon a Voyage any Day, when the Equation found in the Table is Seven Minutes, and the Title [Watch too Slow] I conclude from thence, That a good Watch should be Seven Minuts too slow, or behind the Time given

given by a true Sun-Dial, therefore I put my Watch seven Minuts behind the Time given by the Sun. As suppose I set my Watch at 12 a Clock, I put it to 53 Minuts past 11, or if I set it at 4, I put it to 53 Minuts past 3, &c. and laying it carefully by, as before directed, it is fit for the Voyage.

Suppose I have Sail'd several Days to the *Westward* of the Meridian departed from, but whether *Northwards* or *Southwards* it matters not, finding the Sun just upon the Meridian, I look at my Watch, and find it 16 Minutes past 3 a Clock, and looking in the Equation Table, I find *Watch too Fast* 12 Minutes, therefore I subtract 12 Minutes from the Time given by the Watch 3 Hours, 16 Minutes, the Remainder 3 Hours 4 Minutes, reduced as before directed, gives 46 Deg. 0 Min. the true Difference of Longitude; but if it had been too slow 12 min. you must have added 12 min. to 3h. 16m. &c.

Note, If you set your Watch exactly with the Sun when the Equation is nothing, it will always after that hold the same Equation found in the Table, whether too fast or too slow, and the same Quantity, (if your Watch go right) and that is the Reason, that if you set your Watch when there is Equation, you must give it the Equation answering to that Day, (whether swift or slow) and then it will also hold the same Equation.

If any Body will object, that if a Watch proves wrong and erroneous, it may cause a great Error to be contracted in this Way of finding the Longitude, according to the Slowness or Swiftneſs of the Watch.

I answer, That I agree to; but nevertheless when Watches, as well as other Instruments, are made by a good Workman, and sold to a Gentleman for good and substantial,

substantial, it is commonly expected that they should answer the End for which they were made and bought and if we will suffer this Objection to prevail yet farther, I answer, That with Respect to the Latitude, it may as well be urged, that if our Quadrants, Fore-staves, or other Instruments for that Purpose were made wrong, we should be much deceived in our Observations for the Latitude, and yet how few upon such Suppositions will foolishly desist from the Use of those Instruments for attaining the Latitude; nay, so far are they from that, that when they find an apparent Fault in a Quadrant, they will observe carefully what the Fault is whether Northerly or Southerly, and how much, thereby to regulate their future Observations, and when all is done, you shall rarely find where there are many Quadrants, or many Observers aboard of one and the same Ship, and Observing at one and the same Time, that all their Observations shall be exactly the same, but differ sometimes 6, 8, 10, or 20 Minutes, or sometimes more; and yet these Differences are thought tolerable, and the Mariners continue to use these means, and in a great measure to trust to them notwithstanding; for we must not expect to attain to Infallibility in any Respect, whilst we are Traversing this Terraqueous Globe ——— Not that I would advise any Body to be too credulous, or to take either Watches, or other Instruments, and trust to them as the best, meerly upon the Report of another, unless you know you have great Reason to depend upon the Credit of them that so recommend them: But if you think to make use of this Method for finding the Longitude at Sea, take a Watch along with you that you have had some Experience of ashore, and if you have found that your Watch has gone well ashore, and yet fear that, for the Reasons before mentioned, the may not go so well at Sea, take her along with you upon some short Coast Voyage, where you
can

can every now and then observe whether she keeps her true Motion at Sea as well as ashore, and if you find that, notwithstanding your keeping her so carefully, as before directed, the Clamminess of the Sea Air does (as some suppose) retard her Motion, you may use means to quicken her Motion as much as to counterballance her Dullness occasion'd by the Sea-Air, if any such thing be, (which I cannot believe, if she be kept warm and dry, as before directed) and by this means I do not question but that this Method for finding the Longitude might be render'd as easy and practicable as the usual Methods now in Use, for finding the Latitude by Observation, a Thing very desirable, and therefore deserves to be encouraged, and put in Practice.

I know it is argued by Sailors, (and with good Reason too) that in Places near the Equinoctial, the Degrees of Latitude and Longitude are so nearly equal, and that the Mercator's Chart and plain Chart are so much alike, that Longitude there need not be much regarded; but the greatest Necessity for it, and Difficulty in Attaining it, is in Places nearer the Pole, especially above 60 Degrees of Latitude, where a Degree of Longitude contains not half so many Miles as a Degree of Latitude, which makes the Work more difficult.

I answer, for the Encouragement of those that would put in Practice what is here deliver'd, That the nearer the Poles that you come, and consequently, the lesser the Degrees of Longitude are, the more practicable is this Method, and the less the Errors that can be supposed to be contracted; for in a few Miles Westing or Easting in Latitudes above 60, where the Degrees of Longitude are not half so much as a Degree in the Equinoctial, you may much more sensibly and apparently discern your difference of Longitude there, than nearer the Equinoctial. I have been my self running

5 or 6 Knots due West in Latitude $72^{\circ}30'$, or thereabouts, (I do not exactly remember, but it was in Coming from *Archangel*, about the North Cape of *Finnmark*, the Cape it self lies in Latitude $71^{\circ}22'$, and we did not make the Cape coming Home) and in 24 Hours running, I could very sensibly discern that we had gained about half an Hour: So that when the Glasses were out for 12 a-Clock, (which we had formerly experienced to be very right) it wanted about half an Hour of 12 by the Sun, as near as I could compute, having no Help but the Ship's Glasses to compute it by: The Truth of which is also evident, for in Latitude $72^{\circ}30'$ there is but about 18 Miles to a Degree, and if we run about 135 Miles that 24 Hours, which might be done at the Rate abovesaid, it would answer exactly to $7d. - 30m.$ of Longitude, which is just half an Hour in Time; and hence it is plain that the Difference of Longitude by this Method is more perceptible in great Latitudes than near the Equinoctial.

And that the Errors here contracted are also less, is as evident: For suppose your Watch to be wrong by 4 Minutes of Time, this 4 Minutes, I confess, is a Degree of Longitude in all Latitudes, and in that respect the Error is equal in all Latitudes: But when the Longitude comes to be reduced to Miles, such whereof 60 makes a Degree of a great Circle upon the Earth, you will find that a Degree at or near the Equinoctial, is about 60 Miles, and therefore an Error of 4 Minutes in Time begets an Error of 60 Miles near the Equinoctial; but in Latitude $72^{\circ}30'$ aforesaid, where there is but 18 Miles to a Degree, an Error of 4 Minutes of Time begets an Error of but 18 Miles in Distance; and further North, where the Attaining of Longitude is yet more difficult, the Errors contracted by this Operation will consequently be less, an Error of 6 Leagues being as discernable in Latitude $72^{\circ}30'$ as an Error of

For finding the Longitude.

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20 Leagues near the Equinoctial; so that although Sailing near the Equinoctial is commonly reckoned the easiest in all other Cases, yet by this method the most difficult Cases are become the most practicable and easy: And I think I may, without Presumption, entitle it as useful an Help for finding the Longitude as what has yet been offer'd, and may be very Assisting in that useful Subject, till (if possible) the desired Compleatment thereof be accomplished.

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

A Table

D.	1	2	3	4	D.	1	2	3	4
—	—	—	—	—	—	—	—	—	—
5	1	2	3	4	25	5	10	15	20
6	1	2	3	5	26	5	10	16	21
7	1	3	4	6	27	5	11	16	22
—	—	—	—	—	—	—	—	—	—
8	2	3	5	6	28	6	11	17	22
9	2	4	5	7	30	6	12	18	24
10	2	4	6	8	31	6	12	19	25
—	—	—	—	—	—	—	—	—	—
11	2	4	7	9	33	7	13	20	26
12	2	5	7	10	35	7	14	21	28
13	3	5	8	10	37	7	15	22	30
—	—	—	—	—	—	—	—	—	—
14	3	6	8	11	40	8	16	24	32
15	3	6	9	12	42	8	17	25	34
16	3	6	10	13	46	9	18	28	37
—	—	—	—	—	—	—	—	—	—
17	3	7	10	14	50	10	20	30	40
18	4	7	11	14	55	11	22	33	44
19	4	8	11	15	61	12	24	37	49
—	—	—	—	—	—	—	—	—	—
20	4	8	12	16	68	14	27	41	54
21	4	8	13	17	76	15	30	46	61
22	4	9	13	18	88	18	35	53	70
—	—	—	—	—	—	—	—	—	—
23	5	9	14	18	105	21	42	63	84
24	5	10	14	19	115	23	46	69	92

A TABLE of Logarithms

For Numbers increasing in their Natural Order, from an Unit to 10,000.

With a Table of Artificial *SINES*, *TANGENTS*, and *SECANTS*, the *RADIUS* 10.000000; and to every Degree and Minute of the *Quadrant*.

Num.	Logar.	Num.	Logar.	Num.	Logar.
1	0.000000	34	1.531479	67	1.826075
2	0.301030	35	1.544068	68	1.832509
3	0.477121	36	1.556302	69	1.838849
4	0.602060	37	1.568202	70	1.845098
5	0.698970	38	1.579784	71	1.851258
6	0.778151	39	1.591065	72	1.857332
7	0.845098	40	1.602060	73	1.863323
8	0.903090	41	1.612784	74	1.869232
9	0.954242	42	1.623249	75	1.875061
10	1.000000	43	1.633468	76	1.880814
11	1.041393	44	1.643453	77	1.886491
12	1.079181	45	1.653212	78	1.892095
13	1.113943	46	1.662758	79	1.897627
14	1.146128	47	1.672098	80	1.903090
15	1.176091	48	1.681241	81	1.908485
16	1.204120	49	1.690196	82	1.913814
17	1.230449	50	1.698970	83	1.919078
18	1.255272	51	1.707570	84	1.924279
19	1.278754	52	1.716003	85	1.929419
20	1.301030	53	1.724276	86	1.934498
21	1.322219	54	1.732394	87	1.939519
22	1.342422	55	1.740362	88	1.944483
23	1.361728	56	1.748188	89	1.949390
24	1.380211	57	1.755875	90	1.954242
25	1.397940	58	1.763428	91	1.959041
26	1.414972	59	1.770852	92	1.963788
27	1.431364	60	1.778151	93	1.968483
28	1.447158	61	1.785330	94	1.973128
29	1.462398	62	1.792392	95	1.977724
30	1.477121	63	1.799340	96	1.982271
31	1.491362	64	1.806180	97	1.986772
32	1.505150	65	1.812913	98	1.991226
33	1.518514	66	1.819544	99	1.995635

(384) A Table of Logarithms.

Num.	0	1	2	3	4	Diff.
100	2.000000	2.000434	2.000868	2.001301	2.001734	432
101	2.004321	2.004751	2.005180	2.005609	2.006038	438
102	2.008600	2.009026	2.009451	2.009876	2.010300	444
103	2.012837	2.013259	2.013680	2.014100	2.014520	450
104	2.017032	2.017451	2.017868	2.018284	2.018700	456
105	2.021189	2.021603	2.022016	2.022428	2.022841	462
106	2.025306	2.025715	2.026124	2.026533	2.026942	468
107	2.029384	2.029789	2.030199	2.030600	2.031004	464
108	2.033424	2.033826	2.034227	2.034628	2.035029	470
109	2.037426	2.037825	2.038223	2.038620	2.039017	476
110	2.041398	2.041787	2.042182	2.042575	2.042969	482
111	2.045323	2.045714	2.046105	2.046495	2.046885	488
112	2.049218	2.049606	2.049993	2.050380	2.050766	494
113	2.053078	2.053463	2.053846	2.054230	2.054613	500
114	2.056905	2.057286	2.057666	2.058046	2.058426	506
115	2.060698	2.061075	2.061452	2.061829	2.062206	512
116	2.064458	2.064832	2.065206	2.065580	2.065953	518
117	2.068186	2.068557	2.068928	2.069298	2.069668	524
118	2.071882	2.072250	2.072617	2.072985	2.073352	530
119	2.075547	2.075912	2.076276	2.076640	2.077004	536
120	2.079181	2.079543	2.079904	2.080266	2.080626	542
121	2.082785	2.083144	2.083503	2.083861	2.084219	548
122	2.086360	2.086716	2.087071	2.087426	2.087781	554
123	2.089935	2.090288	2.090641	2.090993	2.091345	560
124	2.093422	2.093772	2.094122	2.094471	2.094820	566
125	2.096910	2.097257	2.097604	2.097951	2.098297	572
126	2.100370	2.100715	2.101059	2.101403	2.101747	578
127	2.103804	2.104145	2.104487	2.104828	2.105169	584
128	2.107210	2.107549	2.107888	2.108227	2.108565	590
129	2.110590	2.110926	2.111262	2.111598	2.111934	596
130	2.113943	2.114277	2.114611	2.114944	2.115278	602
131	2.117271	2.117603	2.117934	2.118265	2.118595	608
132	2.120574	2.120902	2.121231	2.121560	2.121888	614
133	2.122852	2.123178	2.123504	2.123830	2.124156	620
134	2.127105	2.127429	2.127752	2.128076	2.128399	626
135	2.130334	2.130655	2.130977	2.131298	2.131618	632
136	2.133539	2.133858	2.134177	2.134496	2.134814	638
137	2.136721	2.137037	2.137354	2.137670	2.137987	644
138	2.139879	2.140194	2.140508	2.140822	2.141136	650
139	2.143015	2.143327	2.143639	2.143951	2.144263	656
140	2.146128	2.146438	2.146748	2.147058	2.147367	662
141	2.149219	2.149527	2.149835	2.150142	2.150449	668
142	2.152288	2.152594	2.152900	2.153205	2.153510	674

from 1 to 10000.

(385)

Diff.	Num.	5	6	7	8	9	Diff.
432	100	2.002166	2.002598	2.003029	2.003460	2.003891	432
428	101	2.006466	2.006894	2.007321	2.007748	2.008174	428
424	102	2.010724	2.011147	2.011570	2.011993	2.012415	424
419	103	2.014940	2.015356	2.015779	2.016197	2.016615	419
416	104	2.019116	2.019532	2.019947	2.020361	2.020775	416
412	105	2.023252	2.023664	2.024075	2.024486	2.024896	412
408	106	2.027350	2.027757	2.028164	2.028571	2.028978	408
404	107	2.031408	2.031812	2.032216	2.032619	2.033021	404
400	108	2.035430	2.035830	2.036229	2.036629	2.037028	400
396	109	2.039414	2.039810	2.040207	2.040602	2.040998	396
393	110	2.043362	2.043755	2.044148	2.044540	2.044931	393
389	111	2.047275	2.047664	2.048053	2.048442	2.048830	389
386	112	2.051152	2.051538	2.051924	2.052309	2.052694	386
382	113	2.054996	2.055378	2.055760	2.056142	2.056524	382
379	114	2.058805	2.059185	2.059563	2.059942	2.060320	379
376	115	2.062582	2.062958	2.063333	2.063708	2.064083	376
372	116	2.066326	2.066698	2.067071	2.067443	2.067814	372
369	117	2.070038	2.070407	2.070776	2.071145	2.071514	369
366	118	2.073718	2.074085	2.074451	2.074816	2.075182	366
363	119	2.077368	2.077731	2.078094	2.078457	2.078819	363
360	120	2.080987	2.081347	2.081707	2.082067	2.082426	360
357	121	2.084576	2.084934	2.085291	2.085647	2.086004	357
355	122	2.088136	2.088490	2.088845	2.089198	2.089552	355
351	123	2.091667	2.092018	2.092370	2.092721	2.093071	351
349	124	2.095169	2.095518	2.095866	2.096215	2.096562	349
346	125	2.098644	2.098990	2.099335	2.099681	2.100026	346
343	126	2.102090	2.102434	2.102777	2.103119	2.103462	343
340	127	2.105510	2.105851	2.106191	2.106531	2.106870	340
338	128	2.108903	2.109241	2.109578	2.109916	2.110253	338
335	129	2.112270	2.112605	2.112940	2.113275	2.113609	335
333	130	2.115610	2.115943	2.116276	2.116608	2.116940	333
330	131	2.118926	2.119256	2.119586	2.119915	2.120245	330
328	132	2.122216	2.122543	2.122871	2.123198	2.123525	328
325	133	2.125481	2.125806	2.126131	2.126456	2.126781	325
323	134	2.128722	2.129045	2.129368	2.129690	2.130012	323
321	135	2.131939	2.132260	2.132580	2.132900	2.133219	321
318	136	2.135133	2.135451	2.135768	2.136086	2.136403	318
315	137	2.138303	2.138618	2.138934	2.139249	2.139564	315
314	138	2.141450	2.141763	2.142076	2.142389	2.142702	314
311	139	2.144574	2.144885	2.145196	2.145507	2.145818	311
309	140	2.147676	2.147985	2.148294	2.148603	2.148911	309
307	141	2.150756	2.151063	2.151370	2.151676	2.151982	307
305	142	2.153815	2.154119	2.154424	2.154728	2.155032	305

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Num.	0	1	2	3	4	Diff.
143	2.155336	2.155640	2.155943	2.156246	2.156549	303
144	2.158361	2.158664	2.158965	2.159266	2.159567	301
145	2.161368	2.161667	2.161967	2.162266	2.162564	299
146	2.164353	2.164650	2.164947	2.165244	2.165541	297
147	2.167317	2.167613	2.167908	2.168203	2.168497	295
148	2.170262	2.170555	2.170848	2.171141	2.171434	293
149	2.173186	2.173478	2.173769	2.174060	2.174351	291
150	2.176091	2.176381	2.176670	2.176959	2.177248	289
151	2.178977	2.179264	2.179552	2.179839	2.180126	287
152	2.181844	2.182129	2.182415	2.182700	2.182985	285
153	2.184691	2.184975	2.185259	2.185542	2.185825	283
154	2.187521	2.187803	2.188084	2.188366	2.188647	281
155	2.190332	2.190612	2.190892	2.191171	2.191451	279
156	2.193124	2.193403	2.193681	2.193959	2.194237	278
157	2.195900	2.196176	2.196452	2.196729	2.197005	276
158	2.198657	2.198932	2.199206	2.199481	2.199755	274
159	2.201397	2.201670	2.201943	2.202216	2.202488	272
160	2.204120	2.204391	2.204662	2.204933	2.205204	271
161	2.206826	2.207095	2.207365	2.207634	2.207903	269
162	2.209515	2.209783	2.210051	2.210318	2.210586	267
163	2.212188	2.212454	2.212720	2.212986	2.213252	266
164	2.214844	2.215109	2.215373	2.215638	2.215902	264
165	2.217484	2.217747	2.218010	2.218273	2.218535	262
166	2.220168	2.220370	2.220631	2.220892	2.221153	261
167	2.222716	2.222976	2.223236	2.223496	2.223755	259
168	2.225309	2.225568	2.225826	2.226084	2.226342	258
169	2.227887	2.228143	2.228400	2.228657	2.228913	256
170	2.230449	2.230704	2.230960	2.231215	2.231470	254
171	2.232996	2.233250	2.233504	2.233757	2.234011	253
172	2.235528	2.235781	2.236033	2.236285	2.236537	252
173	2.238046	2.238297	2.238548	2.238799	2.239049	250
174	2.240549	2.240799	2.241048	2.241297	2.241546	249
175	2.243038	2.243286	2.243534	2.243782	2.244030	248
176	2.245513	2.245759	2.246006	2.246252	2.246499	246
177	2.247973	2.248219	2.248464	2.248709	2.248954	245
178	2.250420	2.250664	2.250908	2.251151	2.251395	243
179	2.252853	2.253096	2.253338	2.253580	2.253822	242
180	2.255272	2.255514	2.255755	2.255996	2.256237	241
181	2.257670	2.257918	2.258158	2.258398	2.258637	239
182	2.260071	2.260310	2.260548	2.260787	2.261025	238
183	2.262451	2.262688	2.262925	2.263162	2.263399	237
184	2.264818	2.265054	2.265290	2.265525	2.265761	235
185	2.267172	2.267406	2.267641	2.267875	2.268110	234

from 1 to 10000.

(387)

	5	6	7	8	9	Diff.
303	2.156852	2.157134	2.157457	2.157759	2.158061	303
299	2.159868	2.160168	2.160468	2.160769	2.161068	301
297	2.162863	2.163161	2.163459	2.163757	2.164055	299
295	2.165838	2.166134	2.166430	2.166726	2.167022	297
293	2.168792	2.169086	2.169380	2.169674	2.169968	295
291	2.171716	2.172019	2.172311	2.172603	2.172895	293
289	2.174641	2.174932	2.175222	2.175512	2.175802	291
287	2.177536	2.177825	2.178113	2.178401	2.178689	289
285	2.180413	2.180699	2.180986	2.181272	2.181558	287
283	2.183270	2.183554	2.183839	2.184123	2.184407	285
281	2.186108	2.186391	2.186674	2.186956	2.187239	283
279	2.188928	2.189209	2.189490	2.189771	2.190051	281
278	2.191730	2.192009	2.192289	2.192567	2.192846	279
276	2.194514	2.194792	2.195069	2.195346	2.195623	278
274	2.197281	2.197556	2.197832	2.198107	2.198382	276
272	2.200029	2.200303	2.200577	2.200850	2.201124	274
271	2.202761	2.203033	2.203305	2.203577	2.203848	272
269	2.205475	2.205745	2.206016	2.206286	2.206556	271
267	2.208172	2.208441	2.208710	2.208978	2.209246	269
266	2.210853	2.211120	2.211388	2.211654	2.211921	267
264	2.213518	2.213783	2.214049	2.214314	2.214579	266
262	2.216166	2.216430	2.216694	2.216957	2.217221	264
261	2.218798	2.219060	2.219322	2.219584	2.219846	262
259	2.221414	2.221675	2.221936	2.222196	2.222456	261
258	2.224015	2.224274	2.224533	2.224792	2.225051	259
256	2.226600	2.226858	2.227115	2.227372	2.227630	258
254	2.229170	2.229426	2.229682	2.229938	2.230193	256
253	2.231724	2.231979	2.232233	2.232488	2.232743	254
252	2.234264	2.234517	2.234770	2.235023	2.235276	253
250	2.236789	2.237041	2.237292	2.237544	2.237795	252
249	2.239299	2.239549	2.239800	2.240050	2.240299	250
248	2.241795	2.242044	2.242293	2.242541	2.242790	249
246	2.244377	2.244624	2.244872	2.245118	2.245366	248
245	2.246745	2.246991	2.247236	2.247482	2.247728	246
243	2.249198	2.249443	2.249687	2.249932	2.250176	245
242	2.251638	2.251881	2.252125	2.252367	2.252610	243
241	2.254064	2.254306	2.254548	2.254790	2.255031	242
239	2.256477	2.256718	2.256958	2.257198	2.257439	241
238	2.258877	2.259116	2.259355	2.259593	2.259833	239
237	2.261263	2.261501	2.261738	2.261976	2.262214	238
235	2.263626	2.263873	2.264109	2.264345	2.264582	237
234	2.265996	2.266232	2.266467	2.266702	2.266937	235
234	2.268344	2.268578	2.268812	2.269046	2.269279	234

(388)

A Table of Logarithms

Num.	0	1	2	3	4	D
186	2.269513	2.269746	2.269980	2.270213	2.270446	
187	2.271842	2.272074	2.272306	2.272538	2.272770	
188	2.274158	2.274389	2.274620	2.274850	2.275081	
189	2.276462	2.276691	2.276921	2.277151	2.277380	
190	2.278754	2.278982	2.279210	2.279439	2.279667	
191	2.281033	2.281261	2.281488	2.281715	2.281942	
192	2.283301	2.283527	2.283753	2.283979	2.284204	
193	2.285557	2.285782	2.286007	2.286232	2.286456	
194	2.287802	2.288025	2.288249	2.288473	2.288696	
195	2.290035	2.290257	2.290480	2.290702	2.290925	
196	2.292256	2.292478	2.292699	2.292920	2.293141	
197	2.294466	2.294687	2.294907	2.295127	2.295347	
198	2.296665	2.296884	2.297104	2.297323	2.297542	
199	2.298853	2.299071	2.299289	2.299507	2.299725	
200	2.301030	2.301247	2.301464	2.301681	2.301898	
201	2.303196	2.303412	2.303628	2.303844	2.304059	
202	2.305351	2.305566	2.305781	2.305996	2.306210	
203	2.307496	2.307710	2.307924	2.308137	2.308351	
204	2.309630	2.309843	2.310056	2.310268	2.310481	
205	2.311754	2.311966	2.312177	2.312389	2.312600	
206	2.313867	2.314078	2.314289	2.314499	2.314710	
207	2.315970	2.316180	2.316390	2.316599	2.316809	
208	2.318063	2.318272	2.318481	2.318689	2.318898	
209	2.320146	2.320354	2.320562	2.320769	2.320977	
210	2.322219	2.322426	2.322633	2.322839	2.323046	
211	2.324282	2.324488	2.324693	2.324899	2.325105	
212	2.326336	2.326541	2.326745	2.326950	2.327154	
213	2.328380	2.328583	2.328787	2.328991	2.329194	
214	2.330414	2.330617	2.330819	2.331022	2.331225	
215	2.332438	2.332640	2.332842	2.333044	2.333246	
216	2.334454	2.334655	2.334856	2.335056	2.335257	
217	2.336460	2.336660	2.336860	2.337060	2.337260	
218	2.338456	2.338656	2.338855	2.339054	2.339253	
219	2.340444	2.340642	2.340840	2.341039	2.341237	
220	2.342423	2.342620	2.342817	2.343014	2.343212	
221	2.344392	2.344589	2.344785	2.344981	2.345178	
222	2.346353	2.346549	2.346744	2.346939	2.347135	
223	2.348305	2.348499	2.348694	2.348889	2.349083	
224	2.350248	2.350442	2.350636	2.350829	2.351023	
225	2.352182	2.352375	2.352568	2.352761	2.352954	
226	2.354108	2.354301	2.354493	2.354684	2.354876	
227	2.356026	2.356217	2.356408	2.356599	2.356790	
228	2.357935	2.358125	2.358316	2.358506	2.358696	

from 1 to 10000.

(389)

	5	6	7	8	9	Diff.
2.270679	2.270912	2.271144	2.271377	2.271609	233	
2.273001	2.273233	2.273464	2.273696	2.273927	232	
2.275311	2.275542	2.275772	2.276002	2.276232	230	
2.277609	2.277838	2.278067	2.278296	2.278525	229	
2.279895	2.280123	2.280351	2.280578	2.280806	228	
2.282169	2.282395	2.282622	2.282849	2.283075	227	
2.284431	2.284656	2.284882	2.285107	2.285332	226	
2.286681	2.286905	2.287130	2.287354	2.287578	225	
2.288920	2.289143	2.289366	2.289589	2.289812	223	
2.291147	2.291369	2.291591	2.291813	2.292034	222	
2.293362	2.293583	2.293804	2.294025	2.294246	221	
2.295567	2.295787	2.296007	2.296226	2.296446	220	
2.297760	2.297979	2.298198	2.298416	2.298635	219	
2.299943	2.300160	2.300378	2.300595	2.300813	218	
2.302114	2.302331	2.302547	2.302764	2.302980	217	
2.304275	2.304490	2.304706	2.304921	2.305136	216	
2.306425	2.306639	2.306854	2.307068	2.307282	215	
2.308564	2.308778	2.308991	2.309204	2.309417	213	
2.310693	2.310906	2.311118	2.311330	2.311542	212	
2.312812	2.313023	2.313234	2.313445	2.313656	211	
2.314920	2.315130	2.315340	2.315550	2.315760	210	
2.317018	2.317227	2.317436	2.317645	2.317854	209	
2.319106	2.319314	2.319523	2.319730	2.319938	208	
2.321184	2.321391	2.321598	2.321805	2.322012	207	
2.323252	2.323458	2.323664	2.323871	2.324077	206	
2.325310	2.325515	2.325721	2.325926	2.326131	205	
2.327359	2.327563	2.327767	2.327972	2.328176	204	
2.329398	2.329601	2.329804	2.330008	2.330211	203	
2.331427	2.331629	2.331832	2.332034	2.332236	202	
2.333447	2.333649	2.333850	2.334051	2.334253	202	
2.335458	2.335658	2.335859	2.336059	2.336259	201	
2.337459	2.337659	2.337858	2.338058	2.338257	200	
2.339451	2.339650	2.339849	2.340047	2.340246	199	
2.341434	2.341632	2.341830	2.342028	2.342225	198	
2.343409	2.343605	2.343802	2.343999	2.344196	197	
2.345374	2.345570	2.345765	2.345961	2.346157	196	
2.347330	2.347525	2.347720	2.347915	2.348110	195	
2.349277	2.349472	2.349666	2.349860	2.350054	194	
2.351216	2.351410	2.351603	2.351796	2.351989	193	
2.353146	2.353339	2.353532	2.353724	2.353916	193	
2.355068	2.355260	2.355451	2.355643	2.355834	192	
2.356981	2.357172	2.357367	2.357554	2.357744	191	
2.358886	2.359076	2.359266	2.359456	2.359646	190	

Da 3

Num.	0	1	2	3	4	Lin
229	2.359835	2.360025	2.360215	2.360404	2.360593	18
230	2.361728	2.361917	2.362105	2.362294	2.362482	18
231	2.363612	2.363800	2.363987	2.364176	2.364363	18
232	2.365488	2.365675	2.365862	2.366049	2.366236	18
233	2.367356	2.367542	2.367728	2.367915	2.368101	18
234	2.369216	2.369401	2.369587	2.369772	2.369958	18
235	2.371068	2.371253	2.371437	2.371622	2.371806	18
236	2.372912	2.373096	2.373280	2.373464	2.373647	18
237	2.374748	2.374932	2.375115	2.375298	2.375481	18
238	2.376577	2.376759	2.376942	2.377124	2.377306	18
239	2.378398	2.378580	2.378761	2.378943	2.379124	18
240	2.380211	2.380392	2.380573	2.380754	2.380934	18
241	2.382017	2.382197	2.382377	2.382557	2.382737	18
242	2.383815	2.383995	2.384174	2.384353	2.384533	17
243	2.385606	2.385785	2.385964	2.386142	2.386321	17
244	2.387390	2.387568	2.387746	2.387923	2.388101	17
245	2.389166	2.389343	2.389520	2.389697	2.389874	17
246	2.390935	2.391112	2.391288	2.391464	2.391641	17
247	2.392697	2.392873	2.393048	2.393224	2.393400	17
248	2.394452	2.394627	2.394802	2.394977	2.395152	17
249	2.396199	2.396374	2.396548	2.396722	2.396896	17
250	2.397940	2.398114	2.398287	2.398461	2.398634	17
251	2.399674	2.399847	2.400020	2.400192	2.400365	17
252	2.401400	2.401573	2.401745	2.401917	2.402089	17
253	2.403120	2.403292	2.403464	2.403635	2.403807	17
254	2.404834	2.405005	2.405175	2.405346	2.405517	17
255	2.406540	2.406710	2.406881	2.407051	2.407221	17
256	2.408240	2.408409	2.408579	2.408749	2.408918	16
257	2.409933	2.410102	2.410271	2.410440	2.410608	16
258	2.411620	2.411788	2.411956	2.412124	2.412292	16
259	2.413300	2.413467	2.413634	2.413802	2.413970	16
260	2.414973	2.415140	2.415307	2.415474	2.415641	16
261	2.416640	2.416807	2.416973	2.417139	2.417306	16
262	2.418301	2.418467	2.418633	2.418798	2.418964	16
263	2.419956	2.420121	2.420286	2.420451	2.420616	16
264	2.421604	2.421768	2.421933	2.422097	2.422261	16
265	2.423246	2.423410	2.423573	2.423737	2.423901	16
266	2.424882	2.425045	2.425208	2.425371	2.425534	16
267	2.426511	2.426674	2.426836	2.426999	2.427161	16
268	2.428135	2.428297	2.428459	2.428621	2.428782	16
269	2.429752	2.429914	2.430075	2.430236	2.430398	16
270	2.431364	2.431525	2.431685	2.431846	2.432007	16
271	2.432969	2.433129	2.433290	2.433450	2.433610	16

from 1 to 10000.

(391)

Num.	5	6	7	8	9	Diff.
229	2.360783	2.360972	2.361161	2.361350	2.361539	189
230	2.362671	2.362859	2.363048	2.363236	2.363427	188
231	2.364551	2.364739	2.364926	2.365113	2.365301	188
232	2.366423	2.366610	2.366796	2.366983	2.367169	187
233	2.368287	2.368473	2.368659	2.368844	2.369030	186
234	2.370143	2.370328	2.370513	2.370698	2.370883	185
235	2.371991	2.372175	2.372360	2.372544	2.372728	184
236	2.373811	2.374015	2.374198	2.374382	2.374565	184
237	2.375664	2.375846	2.376029	2.376212	2.376394	183
238	2.377488	2.377670	2.377852	2.378034	2.378216	182
239	2.379305	2.379487	2.379668	2.379849	2.380030	181
240	2.381115	2.381296	2.381476	2.381656	2.381837	181
241	2.382917	2.383097	2.383277	2.383456	2.383636	180
242	2.384712	2.384891	2.385070	2.385249	2.385427	179
243	2.386499	2.386677	2.386855	2.387034	2.387212	178
244	2.388279	2.388456	2.388634	2.388811	2.388989	178
245	2.390051	2.390228	2.390405	2.390582	2.390758	177
246	2.391817	2.391993	2.392169	2.392345	2.392521	176
247	2.393575	2.393751	2.393926	2.394101	2.394276	176
248	2.395326	2.395501	2.395676	2.395850	2.396025	175
249	2.397070	2.397245	2.397418	2.397592	2.397766	174
250	2.398808	2.398981	2.399154	2.399327	2.399501	173
251	2.400538	2.400711	2.400880	2.401056	2.401228	173
252	2.402261	2.402433	2.402605	2.402777	2.402949	172
253	2.404078	2.404149	2.404320	2.404492	2.404663	171
254	2.405588	2.405858	2.406029	2.406199	2.406370	171
255	2.407391	2.407561	2.407731	2.407900	2.408070	170
256	2.409087	2.409257	2.409426	2.409595	2.409764	169
257	2.410777	2.410946	2.411114	2.411283	2.411451	169
258	2.412460	2.412628	2.412796	2.412964	2.413132	168
259	2.414137	2.414305	2.414472	2.414639	2.414806	167
260	2.415808	2.415974	2.416141	2.416308	2.416474	167
261	2.417472	2.417638	2.417804	2.417970	2.418135	166
262	2.419129	2.419295	2.419460	2.419625	2.419791	165
263	2.420781	2.420945	2.421110	2.421275	2.421439	165
264	2.422426	2.422590	2.422754	2.422918	2.423082	164
265	2.424064	2.424228	2.424391	2.424555	2.424718	164
266	2.425697	2.425860	2.426023	2.426186	2.426349	163
267	2.427324	2.427486	2.427648	2.427811	2.427973	162
268	2.428944	2.429106	2.429268	2.429429	2.429591	162
269	2.430559	2.430720	2.430881	2.431042	2.431203	161
270	2.432167	2.432328	2.432488	2.432649	2.432809	160
271	2.433770	2.433938	2.434090	2.434249	2.434409	160

Num.	0	1	2	3	4	Diff.
272	2.434509	2.434728	2.434888	2.435048	2.435207	159
273	2.436163	2.436322	2.436481	2.436640	2.436798	159
274	2.437751	2.437909	2.438067	2.438226	2.438384	158
275	2.439333	2.439491	2.439648	2.439806	2.439964	158
276	2.440909	2.441066	2.441224	2.441381	2.441538	157
277	2.442480	2.442636	2.442793	2.442950	2.443108	157
278	2.444045	2.444201	2.444357	2.444513	2.444669	156
279	2.445604	2.445760	2.445915	2.446071	2.446226	155
280	2.447158	2.447313	2.447468	2.447623	2.447778	155
281	2.448706	2.448861	2.449015	2.449170	2.449324	154
282	2.450249	2.450403	2.450557	2.450711	2.450865	154
283	2.451786	2.451940	2.452093	2.452247	2.452400	153
284	2.453318	2.453471	2.453624	2.453777	2.453930	153
285	2.454845	2.454997	2.455149	2.455302	2.455454	152
286	2.456366	2.456518	2.456670	2.456821	2.456973	152
287	2.457882	2.458033	2.458184	2.458336	2.458487	151
288	2.459392	2.459543	2.459694	2.459845	2.459995	151
289	2.460898	2.461048	2.461198	2.461348	2.461498	150
290	2.462398	2.462548	2.462697	2.462847	2.462997	150
291	2.463893	2.464042	2.464191	2.464340	2.464489	149
292	2.465383	2.465532	2.465680	2.465829	2.465977	149
293	2.466868	2.467016	2.467164	2.467312	2.467460	148
294	2.468347	2.468495	2.468643	2.468790	2.468938	147
295	2.469822	2.469969	2.470116	2.470263	2.470410	147
296	2.471292	2.471438	2.471585	2.471732	2.471878	146
297	2.472756	2.472903	2.473049	2.473195	2.473341	146
298	2.474216	2.474362	2.474508	2.474653	2.474799	145
299	2.475671	2.475816	2.475962	2.476107	2.476252	145
300	2.477121	2.477265	2.477411	2.477555	2.477700	145
301	2.478566	2.478711	2.478855	2.478999	2.479143	144
302	2.480007	2.480151	2.480294	2.480438	2.480582	144
303	2.481442	2.481586	2.481729	2.481872	2.482016	143
304	2.482874	2.483016	2.483159	2.483302	2.483445	143
305	2.484300	2.484442	2.484584	2.484727	2.484869	142
306	2.485721	2.485863	2.486005	2.486147	2.486289	142
307	2.487138	2.487280	2.487421	2.487563	2.487704	141
308	2.488551	2.488692	2.488833	2.488973	2.489114	141
309	2.489958	2.490099	2.490239	2.490380	2.490520	140
310	2.491362	2.491502	2.491642	2.491782	2.491922	140
311	2.492760	2.492900	2.493040	2.493179	2.493319	139
312	2.494155	2.494294	2.494433	2.494572	2.494711	139
313	2.495544	2.495683	2.495822	2.495960	2.496099	138
314	2.496930	2.497068	2.497206	2.497344	2.497482	138

from 1 to 10000.

(393)

Diff.	Num.	5	6	7	8	9	Diff
159	272	2.435366	2.435526	2.435685	2.435844	2.436003	159
159	273	2.436957	2.437116	2.437275	2.437433	2.437592	159
158	274	2.438542	2.438700	2.438859	2.439017	2.439175	158
158	275	2.440122	2.440279	2.440437	2.440594	2.440752	158
157	276	2.441695	2.441852	2.442009	2.442166	2.442323	157
157	277	2.443263	2.443419	2.443576	2.443732	2.443888	157
156	278	2.444825	2.444981	2.445137	2.445293	2.445448	156
155	279	2.446382	2.446537	2.446692	2.446848	2.447003	155
155	280	2.447933	2.448088	2.448242	2.448397	2.448552	155
154	281	2.449478	2.449633	2.449787	2.449941	2.450095	154
154	282	2.451018	2.451172	2.451326	2.451479	2.451633	154
153	283	2.452553	2.452706	2.452859	2.453012	2.453165	153
153	284	2.454082	2.454235	2.454387	2.454540	2.454692	153
152	285	2.455606	2.455758	2.455910	2.456062	2.456214	152
152	286	2.457125	2.457276	2.457428	2.457579	2.457730	152
151	287	2.458638	2.458789	2.458940	2.459091	2.459242	151
151	288	2.460146	2.460296	2.460447	2.460597	2.460747	151
150	289	2.461649	2.461799	2.461948	2.462098	2.462248	150
150	290	2.463146	2.463296	2.463445	2.463594	2.463744	150
149	291	2.464639	2.464787	2.464936	2.465085	2.465234	149
149	292	2.466126	2.466274	2.466423	2.466571	2.466719	149
148	293	2.467608	2.467756	2.467904	2.468052	2.468200	148
147	294	2.469085	2.469233	2.469380	2.469527	2.469675	147
147	295	2.470557	2.470704	2.470851	2.470998	2.471145	147
146	296	2.472025	2.472171	2.472317	2.472464	2.472610	146
146	297	2.473487	2.473633	2.473779	2.473925	2.474070	146
145	298	2.474944	2.475090	2.475235	2.475381	2.475526	146
145	299	2.476397	2.476542	2.476687	2.476832	2.476976	145
145	300	2.477844	2.477989	2.478133	2.478278	2.478422	145
144	301	2.479287	2.479431	2.479575	2.479719	2.479863	144
144	302	2.480725	2.480869	2.481012	2.481156	2.481299	144
143	303	2.482159	2.482302	2.482445	2.482588	2.482731	143
143	304	2.483587	2.483730	2.483872	2.484015	2.484157	143
142	305	2.485011	2.485153	2.485295	2.485437	2.485579	142
142	306	2.486430	2.486572	2.486714	2.486855	2.486997	142
141	307	2.487845	2.487986	2.488127	2.488269	2.488410	141
141	308	2.489255	2.489396	2.489537	2.489677	2.489818	141
140	309	2.490661	2.490801	2.490941	2.491081	2.491222	140
140	310	2.492062	2.492201	2.492341	2.492481	2.492621	140
139	311	2.493458	2.493597	2.493737	2.493876	2.494015	139
139	312	2.494850	2.494989	2.495128	2.495267	2.495406	139
139	313	2.496237	2.496376	2.496514	2.496653	2.496791	139
138	314	2.497621	2.497759	2.497897	2.498035	2.498173	138

Num.	0	1	2	3	4	Diff.
315	2.498311	2.498448	2.498586	2.498724	2.498862	138
316	2.499687	2.499824	2.499962	2.500100	2.500236	137
317	2.501059	2.501196	2.501333	2.501470	2.501607	137
318	2.502427	2.502564	2.502700	2.502837	2.502973	136
319	2.503791	2.503927	2.504063	2.504199	2.504335	136
320	2.505150	2.505286	2.505421	2.505557	2.505692	136
321	2.506505	2.506640	2.506775	2.506911	2.507046	135
322	2.507856	2.507991	2.508125	2.508260	2.508395	135
323	2.509202	2.509337	2.509471	2.509606	2.509740	134
324	2.510545	2.510679	2.510813	2.510947	2.511081	134
325	2.511883	2.512017	2.512150	2.512284	2.512417	133
326	2.513218	2.513351	2.513484	2.513617	2.513750	133
327	2.514548	2.514680	2.514813	2.514946	2.515079	133
328	2.515874	2.516005	2.516139	2.516271	2.516403	132
329	2.517196	2.517328	2.517460	2.517592	2.517724	132
330	2.518514	2.518645	2.518777	2.518907	2.519040	131
331	2.519828	2.519959	2.520090	2.520221	2.520352	131
332	2.522138	2.522269	2.522400	2.522530	2.522661	131
333	2.522444	2.522575	2.522705	2.522835	2.522966	130
334	2.523746	2.523876	2.524006	2.524136	2.524266	130
335	2.525045	2.525174	2.525304	2.525433	2.525563	129
336	2.526339	2.526468	2.526598	2.526727	2.526856	129
337	2.527630	2.527759	2.527888	2.528016	2.528145	129
338	2.528917	2.529045	2.529174	2.529302	2.529430	128
339	2.530200	2.530328	2.530456	2.530584	2.530712	128
340	2.531479	2.531607	2.531734	2.531862	2.531989	128
341	2.532754	2.532882	2.533009	2.533136	2.533263	127
342	2.534026	2.534153	2.534280	2.534407	2.534534	127
343	2.535294	2.535421	2.535547	2.535674	2.535800	126
344	2.536558	2.536685	2.536811	2.536937	2.537063	126
345	2.537819	2.537945	2.538071	2.538197	2.538322	126
346	2.539076	2.539202	2.539327	2.539452	2.539578	125
347	2.540329	2.540455	2.540580	2.540705	2.540830	125
348	2.541579	2.541704	2.541829	2.541953	2.542078	125
349	2.542825	2.542950	2.543074	2.543199	2.543323	124
350	2.544068	2.544192	2.544316	2.544440	2.544564	124
351	2.545307	2.545431	2.545554	2.545678	2.545802	124
352	2.546543	2.546666	2.546789	2.546913	2.547036	123
353	2.547775	2.547898	2.548021	2.548144	2.548266	123
354	2.549003	2.549126	2.549246	2.549371	2.549494	123
355	2.550228	2.550351	2.550473	2.550595	2.550717	122
356	2.551450	2.551572	2.551694	2.551816	2.551938	122
357	2.552668	2.552790	2.552911	2.553033	2.553154	121

from 1 to 10000.

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Num.	5	6	7	8	9	Diff
315	2.498999	2.499137	2.499275	2.499412	2.499550	138
316	2.500374	2.500511	2.500648	2.500785	2.500922	137
317	2.501744	2.501880	2.502017	2.502154	2.502290	137
318	2.503109	2.503246	2.503382	2.503518	2.503654	136
319	2.504471	2.504607	2.504743	2.504878	2.505014	136
320	2.505828	2.505963	2.506099	2.506234	2.506370	136
321	2.507181	2.507316	2.507451	2.507586	2.507721	135
322	2.508530	2.508664	2.508799	2.508933	2.509068	135
323	2.509874	2.510008	2.510143	2.510277	2.510411	134
324	2.511215	2.511348	2.511482	2.511616	2.511750	134
325	2.512551	2.512684	2.512818	2.512951	2.513084	133
326	2.513883	2.514016	2.514149	2.514282	2.514415	133
327	2.515211	2.515344	2.515476	2.515609	2.515741	133
328	2.516535	2.516668	2.516800	2.516932	2.517064	132
329	2.517855	2.517987	2.518119	2.518251	2.518382	132
330	2.519171	2.519303	2.519434	2.519565	2.519697	131
331	2.520483	2.520614	2.520745	2.520876	2.521007	131
332	2.521792	2.521922	2.522053	2.522183	2.522314	131
333	2.523096	2.523226	2.523356	2.523486	2.523616	130
334	2.524396	2.524526	2.524656	2.524785	2.524915	130
335	2.525992	2.525822	2.525951	2.526081	2.526210	129
336	2.526985	2.527114	2.527243	2.527372	2.527501	129
337	2.528274	2.528402	2.528531	2.528660	2.528788	129
338	2.529559	2.529687	2.529815	2.529943	2.530072	128
339	2.530840	2.530968	2.531095	2.531223	2.531351	128
340	2.532117	2.532245	2.532372	2.532500	2.532627	128
341	2.533391	2.533518	2.533645	2.533772	2.533899	127
342	2.534661	2.534787	2.534914	2.535041	2.535167	127
343	2.535927	2.536053	2.536179	2.536306	2.536432	126
344	2.537189	2.537315	2.537441	2.537567	2.537693	126
345	2.538448	2.538574	2.538699	2.538825	2.538951	126
346	2.539703	2.539828	2.539954	2.540079	2.540204	125
347	2.540955	2.541080	2.541205	2.541330	2.541454	125
348	2.542203	2.542327	2.542452	2.542576	2.542701	125
349	2.543447	2.543571	2.543696	2.543820	2.543944	124
350	2.544688	2.544812	2.544936	2.545060	2.545183	124
351	2.545925	2.546049	2.546172	2.546296	2.546419	124
352	2.547159	2.547282	2.547405	2.547529	2.547652	123
353	2.548389	2.548512	2.548635	2.548758	2.548881	123
354	2.549616	2.549739	2.549861	2.549984	2.550106	123
355	2.550840	2.550962	2.551084	2.551206	2.551328	122
356	2.552059	2.552181	2.552303	2.552425	2.552546	122
357	2.553276	2.553397	2.553519	2.553640	2.553762	121

Num.	0	1	2	3	4	1114
358	2.553883	2.554004	2.554126	2.554247	2.554368	121
359	2.555094	2.555215	2.555336	2.555457	2.555578	121
360	2.556302	2.556423	2.556544	2.556664	2.556785	120
361	2.557507	2.557627	2.557748	2.557868	2.557988	120
362	1.558709	2.558828	2.558948	2.559068	2.559188	120
363	2.559907	2.560026	2.560146	2.560265	2.560385	119
364	2.561101	2.561221	2.561340	2.561459	2.561578	119
365	2.562293	2.562412	2.562531	2.562650	2.562768	119
366	2.563481	2.563600	2.563718	2.563837	2.563955	119
367	2.564666	2.564784	2.564903	2.565021	2.565139	118
368	2.565848	2.565966	2.566084	2.566202	2.566320	118
369	2.567026	2.567144	2.567262	2.567379	2.567497	118
370	2.568202	2.568319	2.568436	2.568554	2.568671	117
371	2.569374	2.569491	2.569608	2.569725	2.569842	117
372	2.570543	2.570660	2.570776	2.570893	2.571010	117
373	2.571709	2.571825	2.571942	2.572058	2.572174	116
374	2.572872	2.572988	2.573104	2.573220	2.573336	116
375	2.574031	2.574147	2.574263	2.574379	2.574494	116
376	2.575188	2.575303	2.575419	2.575534	2.575650	115
377	2.576341	2.576456	2.576572	2.576687	2.576802	115
378	2.577492	2.577607	2.577721	2.577836	2.577951	115
379	2.578639	2.578754	2.578868	2.578983	2.579097	114
380	2.579784	2.579898	2.580012	2.580126	2.580240	114
381	2.580925	2.581039	2.581153	2.581267	2.581381	114
382	2.582063	2.582177	2.582291	2.582404	2.582518	114
383	2.583199	2.583312	2.583425	2.583539	2.583652	113
384	2.584331	2.584444	2.584557	2.584670	2.584783	113
385	2.585461	2.585573	2.585686	2.585799	2.585912	113
386	2.586587	2.586700	2.586812	2.586925	2.587037	112
387	2.587711	2.587823	2.587935	2.588047	2.588160	112
388	2.588832	2.588944	2.589055	2.589167	2.589279	112
389	2.589950	2.590061	2.590173	2.590284	2.590396	112
390	2.591065	2.591176	2.591287	2.591398	2.591510	111
391	2.592177	2.592288	2.592399	2.592510	2.592621	111
392	2.593286	2.593397	2.593508	2.593618	2.593729	111
393	2.594392	2.594503	2.594613	2.594724	2.594834	110
394	2.595496	2.595606	2.595717	2.595827	2.595937	110
395	2.596597	2.596707	2.596817	2.596927	2.597037	110
396	2.597695	2.597805	2.597914	2.598024	2.598134	110
397	2.598790	2.598900	2.599009	2.599119	2.599228	109
398	2.599883	2.599992	2.600101	2.600210	2.600319	109
399	2.600973	2.601082	2.601190	2.601299	2.601408	109
400	2.602060	2.602168	2.602277	2.602386	2.602494	108

from 1 to 10000.

(397)

Num.	5	6	7	8	9	Diff.
358	2.554489	2.554610	2.554731	2.554852	2.554973	121
359	2.555699	2.555820	2.555940	2.556061	2.556182	121
360	2.556905	2.557026	2.557146	2.557266	2.557387	120
361	2.558108	2.558228	2.558348	2.558469	2.558589	120
362	2.559308	2.559428	2.559548	2.559667	2.559787	120
363	2.560504	2.560624	2.560743	2.560863	2.560982	119
364	2.561697	2.561817	2.561936	2.562055	2.562174	119
365	2.562887	2.563006	2.563125	2.563244	2.563362	119
366	2.564074	2.564192	2.564311	2.564429	2.564548	119
367	2.565257	2.565375	2.565494	2.565612	2.565730	118
368	2.566437	2.566555	2.566673	2.566791	2.566909	118
369	2.567614	2.567732	2.567849	2.567967	2.568084	118
370	2.568788	2.568905	2.569023	2.569140	2.569257	117
371	2.569959	2.570076	2.570193	2.570309	2.570426	117
372	2.571126	2.571243	2.571350	2.571476	2.571592	117
373	2.572291	2.572407	2.572523	2.572639	2.572755	116
374	2.573452	2.573568	2.573684	2.573800	2.573915	116
375	2.574610	2.574726	2.574841	2.574957	2.575072	116
376	2.575765	2.575880	2.575996	2.576111	2.576226	115
377	2.576917	2.577032	2.577147	2.577262	2.577377	115
378	2.578066	2.578181	2.578295	2.578410	2.578525	115
379	2.579212	2.579326	2.579441	2.579555	2.579669	114
380	2.580355	2.580469	2.580583	2.580697	2.580811	114
381	2.581495	2.581608	2.581722	2.581836	2.581950	114
382	2.582631	2.582745	2.582858	2.582972	2.583085	114
383	2.583765	2.583879	2.583992	2.584105	2.584218	113
384	2.584896	2.585009	2.585122	2.585235	2.585348	113
385	2.586024	2.586137	2.586250	2.586362	2.586475	113
386	2.587149	2.587262	2.587374	2.587486	2.587599	112
387	2.588272	2.588384	2.588496	2.588608	2.588720	112
388	2.589391	2.589503	2.589614	2.589726	2.589838	112
389	2.590507	2.590619	2.590730	2.590842	2.590953	112
390	2.591621	2.591732	2.591843	2.591955	2.592066	111
391	2.592732	2.592843	2.592954	2.593064	2.593175	111
392	2.593840	2.593950	2.594061	2.594171	2.594282	111
393	2.594945	2.595055	2.595165	2.595276	2.595386	110
394	2.596047	2.596157	2.596267	2.596377	2.596487	110
395	2.597146	2.597255	2.597366	2.597476	2.597585	110
396	2.598243	2.598353	2.598462	2.598572	2.598681	110
397	2.599337	2.599446	2.599556	2.599665	2.599774	109
398	2.600428	2.600537	2.600646	2.600755	2.600864	109
399	2.601517	2.601625	2.601734	2.601843	2.601951	109
400	2.602602	2.602711	2.602819	2.602928	2.603036	108

Num.	0	1	2	3	4	Diff.
401	2.603144	2.603253	2.603361	2.603469	2.603577	108
402	2.604226	2.604334	2.604442	2.604550	2.604658	108
403	2.605305	2.605413	2.605520	2.605628	2.605736	108
404	2.606381	2.606489	2.606596	2.606704	2.606811	107
405	2.607455	2.607562	2.607669	2.607777	2.607884	107
406	2.608526	2.608633	2.608740	2.608847	2.608954	107
407	2.609594	2.609701	2.609808	2.609914	2.610021	107
408	2.610660	2.610767	2.610873	2.610979	2.611086	106
409	2.611723	2.611829	2.611936	2.612042	2.612148	106
410	2.612784	2.612890	2.612996	2.613102	2.613207	106
411	2.613842	2.613947	2.614053	2.614159	2.614264	106
412	2.614897	2.615003	2.615108	2.615213	2.615319	105
413	2.615950	2.616055	2.616160	2.616265	2.616370	105
414	2.617000	2.617105	2.617210	2.617315	2.617420	105
415	2.618048	2.618153	2.618257	2.618362	2.618466	105
416	2.619093	2.619198	2.619302	2.619406	2.619511	104
417	2.620136	2.620240	2.620344	2.620448	2.620552	104
418	2.621176	2.621280	2.621384	2.621488	2.621592	104
419	2.622214	2.622318	2.622421	2.622525	2.622628	104
420	2.623249	2.623353	2.623456	2.623559	2.623663	103
421	2.624282	2.624385	2.624488	2.624591	2.624694	103
422	2.625312	2.625415	2.625518	2.625621	2.625724	103
423	2.626340	2.626443	2.626546	2.626648	2.626751	103
424	2.627366	2.627468	2.627571	2.627673	2.627775	102
425	2.628389	2.628491	2.628593	2.628695	2.628797	102
426	2.629410	2.629511	2.629613	2.629715	2.629817	102
427	2.630428	2.630529	2.630631	2.630733	2.630834	102
428	2.631444	2.631545	2.631647	2.631748	2.631849	101
429	2.632457	2.632558	2.632660	2.632761	2.632862	101
430	2.633468	2.633569	2.633670	2.633771	2.633872	100
431	2.634477	2.634578	2.634679	2.634779	2.634880	100
432	2.635484	2.635584	2.635685	2.635785	2.635886	100
433	2.636488	2.636588	2.636688	2.636789	2.636889	100
434	2.637490	2.637590	2.637690	2.637790	2.637890	99
435	2.638489	2.638589	2.638689	2.638789	2.638888	99
436	2.639486	2.639580	2.639686	2.639785	2.639885	99
437	2.640481	2.640581	2.640680	2.640779	2.640879	99
438	2.641474	2.641573	2.641672	2.641771	2.641870	99
439	2.642464	2.642503	2.642662	2.642761	2.642860	99
440	2.643453	2.643551	2.643650	2.643749	2.643847	98
441	2.644439	2.644537	2.644635	2.644734	2.644832	98
442	2.645422	2.645520	2.645619	2.645717	2.645815	98
443	2.646404	2.646502	2.646600	2.646698	2.646796	98

Num.	5	6	7	8	9	Diff.
401	2.603685	2.603794	2.603902	2.604010	2.604118	108
402	2.604766	2.604874	2.604982	2.605089	2.605197	108
403	2.605843	2.605950	2.606059	2.606166	2.606274	108
404	2.606918	2.607026	2.607133	2.607240	2.607348	107
405	2.607991	2.608098	2.608205	2.608312	2.608419	107
406	2.609060	2.609167	2.609274	2.609381	2.609488	107
407	2.610128	2.610234	2.610341	2.610447	2.610554	107
408	2.611192	2.611298	2.611405	2.611511	2.611617	106
409	2.612254	2.612360	2.612466	2.612572	2.612678	106
410	2.613313	2.613419	2.613525	2.613630	2.613736	106
411	2.614370	2.614475	2.614581	2.614686	2.614792	106
412	2.615424	2.615529	2.615634	2.615740	2.615845	105
413	2.616475	2.616580	2.616685	2.616790	2.616895	105
414	2.617524	2.617629	2.617734	2.617839	2.617943	105
415	2.618571	2.618675	2.618780	2.618884	2.618989	105
416	2.619615	2.619719	2.619823	2.619928	2.620032	104
417	2.620656	2.620760	2.620864	2.620968	2.621072	104
418	2.621695	2.621799	2.621903	2.622007	2.622110	104
419	2.622732	2.622835	2.622939	2.623042	2.623146	104
420	2.623766	2.623869	2.623972	2.624076	2.624179	103
421	2.624798	2.624901	2.625004	2.625107	2.625209	103
422	2.625827	2.625929	2.626032	2.626135	2.626238	103
423	2.626853	2.626956	2.627058	2.627161	2.627263	103
424	2.627878	2.627980	2.628082	2.628184	2.628287	102
425	2.628900	2.629002	2.629104	2.629206	2.629308	102
426	2.629919	2.630021	2.630123	2.630224	2.630326	102
427	2.630936	2.631038	2.631139	2.631241	2.631342	102
428	2.631951	2.632052	2.632153	2.632255	2.632356	101
429	2.632963	2.633064	2.633165	2.633266	2.633367	101
430	2.633973	2.634074	2.634175	2.634276	2.634376	100
431	2.634981	2.635081	2.635182	2.635283	2.635383	100
432	2.635986	2.636086	2.636187	2.636287	2.636388	100
433	2.636989	2.637089	2.637189	2.637289	2.637390	100
434	2.637990	2.638090	2.638190	2.638289	2.638389	99
435	2.638988	2.639088	2.639188	2.639287	2.639387	99
436	2.639984	2.640084	2.640183	2.640283	2.640382	99
437	2.640978	2.641077	2.641176	2.641276	2.641375	99
438	2.641970	2.642069	2.642168	2.642267	2.642366	99
439	2.642959	2.643058	2.643156	2.643255	2.643354	99
440	2.643946	2.644044	2.644143	2.644242	2.644340	98
441	2.644931	2.645029	2.645127	2.645226	2.645324	98
442	2.645913	2.646011	2.646109	2.646208	2.646306	98
443	2.646894	2.646991	2.647099	2.647189	2.647285	98

(400)

A Table of Logarithms

Num.	0	1	2	3	4	Diff.
444	2.647383	2.647481	2.647578	2.647676	2.647774	98
445	2.648360	2.648458	2.648555	2.648653	2.648750	97
446	2.649335	2.649432	2.649530	2.649627	2.649724	97
447	2.650307	2.650405	2.650502	2.650599	2.650696	97
448	2.651278	2.651375	2.651472	2.651569	2.651666	97
449	2.652246	2.652343	2.652440	2.652536	2.652633	97
450	2.653212	2.653309	2.653405	2.653502	2.653598	96
451	2.654176	2.654273	2.654369	2.654465	2.654562	96
452	2.655138	2.655234	2.655331	2.655427	2.655523	96
453	2.656098	2.656194	2.656290	2.656386	2.656481	96
454	2.657056	2.657151	2.657247	2.657343	2.657438	96
455	2.658011	2.658107	2.658202	2.658298	2.658393	95
456	2.658965	2.659060	2.659155	2.659250	2.659346	95
457	2.659916	2.660011	2.660106	2.660201	2.660296	95
458	2.660865	2.660960	2.661055	2.661150	2.661245	95
459	2.661813	2.661907	2.662002	2.662096	2.662191	95
460	2.662758	2.662852	2.662947	2.663041	2.663135	94
461	2.663701	2.663795	2.663889	2.663983	2.664078	94
462	2.664642	2.664736	2.664830	2.664924	2.665018	94
463	2.665581	2.665675	2.665768	2.665862	2.665956	94
464	2.666518	2.666612	2.666705	2.666799	2.666892	94
465	2.667453	2.667546	2.667640	2.667733	2.667826	93
466	2.668386	2.668479	2.668572	2.668665	2.668758	93
467	2.669317	2.669410	2.669503	2.669596	2.669689	93
468	2.670246	2.670339	2.670431	2.670524	2.670617	93
469	2.671173	2.671265	2.671358	2.671451	2.671543	93
470	2.672098	2.672190	2.672283	2.672375	2.672467	92
471	2.673021	2.673113	2.673205	2.673297	2.673390	92
472	2.673942	2.674034	2.674126	2.674218	2.674310	92
473	2.674861	2.674953	2.675045	2.675136	2.675228	92
474	2.675778	2.675870	2.675961	2.676053	2.676145	92
475	2.676694	2.676785	2.676876	2.676968	2.677059	91
476	2.677607	2.677698	2.677789	2.677881	2.677972	91
477	2.678518	2.678609	2.678700	2.678791	2.678882	91
478	2.679428	2.679519	2.679610	2.679700	2.679791	91
479	2.680335	2.680426	2.680517	2.680607	2.680698	91
480	2.681241	2.681332	2.681422	2.681513	2.681603	90
481	2.682145	2.682235	2.682326	2.682416	2.682506	90
482	2.683047	2.683137	2.683227	2.683317	2.683407	90
483	2.683947	2.684037	2.684127	2.684217	2.684307	90
484	2.684845	2.684935	2.685025	2.685114	2.685204	90
485	2.685742	2.685831	2.685921	2.686010	2.686100	89
486	2.686636	2.686726	2.686815	2.686904	2.686994	89

from 1 to 10000.

(401)

Diff.	Num.	5	6	7	8	9	Diff.
98	444	2.647872	2.647969	2.648067	2.648165	2.648262	98
97	445	2.648848	2.648945	2.649043	2.649140	2.649237	97
97	446	2.649821	2.649919	2.650016	2.650113	2.650210	97
97	447	2.650793	2.650890	2.650987	2.651084	2.651181	97
97	448	2.651762	2.651856	2.651956	2.652053	2.652150	97
97	449	2.652730	2.652826	2.652923	2.653019	2.653116	97
96	450	2.653695	2.653791	2.653888	2.653984	2.654080	96
96	451	2.654658	2.654754	2.654850	2.654946	2.655042	96
96	452	2.655619	2.655714	2.655810	2.655906	2.656002	96
96	453	2.656577	2.656673	2.656769	2.656864	2.656960	96
96	454	2.657534	2.657629	2.657725	2.657820	2.657916	96
95	455	2.658488	2.658584	2.658679	2.658774	2.658870	95
95	456	2.659441	2.659536	2.659631	2.659726	2.659821	95
95	457	2.660391	2.660486	2.660581	2.660676	2.660771	95
95	458	2.661339	2.661434	2.661529	2.661623	2.661718	95
95	459	2.662285	2.662380	2.662474	2.662569	2.662663	95
94	460	2.663230	2.663324	2.663418	2.663512	2.663607	94
94	461	2.664172	2.664266	2.664360	2.664454	2.664548	94
94	462	2.665112	2.665206	2.665299	2.665393	2.665487	94
94	463	2.666050	2.666143	2.666237	2.666331	2.666424	94
94	464	2.666985	2.667079	2.667173	2.667266	2.667359	94
93	465	2.667920	2.668013	2.668106	2.668199	2.668293	93
93	466	2.668852	2.668945	2.669038	2.669131	2.669224	93
93	467	2.669782	2.669874	2.669967	2.670060	2.670153	93
93	468	2.670710	2.670802	2.670895	2.670988	2.671080	93
93	469	2.671636	2.671728	2.671821	2.671913	2.672005	93
92	470	2.672560	2.672652	2.672744	2.672836	2.672929	92
92	471	2.673482	2.673574	2.673666	2.673758	2.673850	92
92	472	2.674402	2.674494	2.674586	2.674677	2.674769	92
92	473	2.675320	2.675412	2.675503	2.675595	2.675687	92
92	474	2.676236	2.676328	2.676419	2.676511	2.676602	92
91	475	2.677150	2.677242	2.677333	2.677424	2.677516	91
91	476	2.678063	2.678154	2.678245	2.678336	2.678427	91
91	477	2.678973	2.679064	2.679155	2.679246	2.679337	91
91	478	2.679882	2.679973	2.680063	2.680154	2.680245	91
91	479	2.680789	2.680879	2.680970	2.681060	2.681151	91
90	480	2.681693	2.681784	2.681874	2.681964	2.682055	90
90	481	2.682596	2.682686	2.682777	2.682867	2.682957	90
90	482	2.683497	2.683587	2.683677	2.683767	2.683857	90
90	483	2.684396	2.684486	2.684576	2.684666	2.684756	90
90	484	2.685294	2.685383	2.685473	2.685563	2.685652	90
89	485	2.686189	2.686279	2.686368	2.686457	2.686547	89
89	486	2.687083	2.687172	2.687261	2.687351	2.687440	89

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Num.	0	1	2	3	4	Diff.
487	2.687529	2.687618	2.687707	2.687796	2.687885	89
488	2.688420	2.688509	2.688598	2.688687	2.688776	89
489	2.689309	2.689398	2.689486	2.689575	2.689664	89
490	2.690196	2.690285	2.690373	2.690462	2.690550	89
491	2.691081	2.691170	2.691258	2.691347	2.691435	88
492	2.691965	2.692053	2.692142	2.692230	2.692318	88
493	2.692847	2.692935	2.693023	2.693111	2.693199	88
494	2.693727	2.693815	2.693903	2.693991	2.694078	88
495	2.694605	2.694693	2.694781	2.694868	2.694956	88
496	2.695482	2.695569	2.695657	2.695744	2.695832	87
497	2.696356	2.696444	2.696531	2.696618	2.696706	87
498	2.697229	2.697316	2.697404	2.697491	2.697578	87
499	2.698100	2.698188	2.698275	2.698362	2.698448	87
500	2.698970	2.699057	2.699144	2.699230	2.699317	87
501	2.699838	2.699924	2.700011	2.700098	2.700184	87
502	2.700704	2.700790	2.700877	2.700963	2.701050	86
503	2.701568	2.701654	2.701741	2.701827	2.701913	86
504	2.702430	2.702517	2.702603	2.702689	2.702775	86
505	2.703291	2.703377	2.703463	2.703549	2.703635	86
506	2.704150	2.704236	2.704322	2.704408	2.704494	86
507	2.705008	2.705094	2.705179	2.705265	2.705350	86
508	2.705864	2.705949	2.706035	2.706120	2.706205	85
509	2.706718	2.706803	2.706888	2.706974	2.707059	85
510	2.707570	2.707655	2.707740	2.707826	2.707911	85
511	2.708421	2.708506	2.708591	2.708676	2.708761	85
512	2.709270	2.709355	2.709440	2.709524	2.709609	85
513	2.710117	2.710202	2.710287	2.710371	2.710456	85
514	2.710963	2.711048	2.711132	2.711216	2.711301	84
515	2.711807	2.711891	2.711976	2.712060	2.712144	84
516	2.712650	2.712734	2.712818	2.712902	2.712986	84
517	2.713450	2.713534	2.713618	2.713702	2.713786	84
518	2.714300	2.714384	2.714467	2.714551	2.714635	84
519	2.715167	2.715251	2.715335	2.715418	2.715502	84
520	2.716003	2.716087	2.716170	2.716254	2.716337	83
521	2.716828	2.716911	2.717004	2.717088	2.717171	83
522	2.717670	2.717754	2.717837	2.717920	2.718003	83
523	2.718502	2.718585	2.718668	2.718751	2.718834	83
524	2.719331	2.719414	2.719497	2.719580	2.719663	83
525	2.720159	2.720241	2.720325	2.720407	2.720490	83
526	2.720986	2.721068	2.721151	2.721233	2.721316	82
527	2.721811	2.721893	2.721975	2.722058	2.722140	82
528	2.722634	2.722716	2.722798	2.722881	2.722963	82
529	2.723456	2.723538	2.723622	2.723702	2.723784	82

from 1 to 10000.

(403)

Num	5	6	7	8	9	Diff.
487	2.687975	2.688064	2.688153	2.688242	2.688331	89
488	2.688865	2.688953	2.689042	2.689131	2.689220	89
489	2.689753	2.689841	2.689930	2.690019	2.690107	89
490	2.690639	2.690727	2.690816	2.690905	2.690993	89
491	2.691523	2.691612	2.691700	2.691788	2.691877	88
492	2.692406	2.692494	2.692583	2.692671	2.692759	88
493	2.693287	2.693375	2.693463	2.693551	2.693639	88
494	2.694166	2.694254	2.694342	2.694430	2.694517	88
495	2.695044	2.695131	2.695219	2.695306	2.695394	88
496	2.695919	2.696007	2.696094	2.696182	2.696269	87
497	2.696793	2.696880	2.696968	2.697055	2.697142	87
498	2.697665	2.697752	2.697839	2.697926	2.698013	87
499	2.698535	2.698622	2.698709	2.698796	2.698883	87
500	2.699404	2.699491	2.699578	2.699664	2.699751	87
501	2.700271	2.700357	2.700444	2.700531	2.700617	87
502	2.701136	2.701222	2.701309	2.701395	2.701482	86
503	2.701999	2.702086	2.702172	2.702258	2.702344	86
504	2.702861	2.702947	2.703033	2.703119	2.703205	86
505	2.703721	2.703807	2.703893	2.703979	2.704065	86
506	2.704579	2.704665	2.704751	2.704837	2.704922	86
507	2.705436	2.705522	2.705607	2.705693	2.705778	86
508	2.706291	2.706376	2.706462	2.706547	2.706632	85
509	2.707144	2.707229	2.707315	2.707400	2.707485	85
510	2.707996	2.708081	2.708166	2.708251	2.708336	85
511	2.708846	2.708931	2.709015	2.709100	2.709185	85
512	2.709694	2.709779	2.709863	2.709948	2.710033	85
513	2.710540	2.710625	2.710710	2.710794	2.710879	85
514	2.711385	2.711470	2.711554	2.711638	2.711723	84
515	2.712229	2.712313	2.712397	2.712481	2.712565	84
516	2.713070	2.713154	2.713238	2.713322	2.713406	84
517	2.713910	2.713994	2.714078	2.714162	2.714246	84
518	2.714749	2.714832	2.714916	2.715000	2.715084	84
519	2.715586	2.715669	2.715753	2.715836	2.715920	84
520	2.716421	2.716504	2.716588	2.716671	2.716754	83
521	2.717254	2.717338	2.717421	2.717504	2.717587	83
522	2.718086	2.718169	2.718253	2.718336	2.718419	83
523	2.718917	2.719000	2.719083	2.719165	2.719248	83
524	2.719745	2.719828	2.719911	2.719994	2.720077	83
525	2.720573	2.720655	2.720738	2.720821	2.720903	83
526	2.721398	2.721481	2.721563	2.721646	2.721728	82
527	2.722222	2.722305	2.722387	2.722469	2.722552	82
528	2.723045	2.723127	2.723209	2.723291	2.723374	82
529	2.723866	2.723948	2.724030	2.724112	2.724194	82

Num.	0	1	2	3	4	Diff.
530	2.724276	2.724358	2.724440	2.724522	2.724603	82
531	2.725094	2.725176	2.725258	2.725340	2.725421	82
532	2.725912	2.725993	2.726075	2.726156	2.726238	82
533	2.726727	2.726809	2.726890	2.726972	2.727053	81
534	2.727541	2.727623	2.727704	2.727785	2.727866	81
535	2.728354	2.728435	2.728516	2.728597	2.728678	81
536	2.729165	2.729246	2.729327	2.729408	2.729489	81
537	2.729974	2.730055	2.730136	2.730217	2.730298	81
538	2.730782	2.730863	2.730944	2.731024	2.731105	81
539	2.731589	2.731669	2.731750	2.731830	2.731911	81
540	2.732394	2.732474	2.732555	2.732635	2.732715	80
541	2.733197	2.733277	2.733358	2.733438	2.733518	80
542	2.733999	2.734079	2.734159	2.734240	2.734320	80
543	2.734800	2.734880	2.734960	2.735040	2.735120	80
544	2.735599	2.735679	2.735758	2.735838	2.735918	80
545	2.736396	2.736476	2.736556	2.736635	2.736715	80
546	2.737193	2.737272	2.737352	2.737431	2.737511	79
547	2.737987	2.738067	2.738146	2.738225	2.738305	79
548	2.738781	2.738860	2.738939	2.739018	2.739097	79
549	2.739572	2.739651	2.739730	2.739810	2.739889	79
550	2.740363	2.740442	2.740521	2.740599	2.740678	79
551	2.741152	2.741230	2.741309	2.741388	2.741467	79
552	2.741939	2.742018	2.742096	2.742175	2.742254	79
553	2.742725	2.742804	2.742882	2.742961	2.743039	78
554	2.743510	2.743588	2.743666	2.743745	2.743823	78
555	2.744293	2.744371	2.744449	2.744528	2.744606	78
556	2.745075	2.745153	2.745231	2.745309	2.745387	78
557	2.745855	2.745933	2.746011	2.746089	2.746167	78
558	2.746634	2.746712	2.746790	2.746868	2.746945	78
559	2.747412	2.747489	2.747567	2.747645	2.747722	78
560	2.748188	2.748265	2.748343	2.748421	2.748498	77
561	2.748963	2.749040	2.749118	2.749195	2.749272	77
562	2.749736	2.749814	2.749891	2.749968	2.750045	77
563	2.750508	2.750586	2.750663	2.750740	2.750817	77
564	2.751279	2.751356	2.751433	2.751510	2.751587	77
565	2.752048	2.752125	2.752202	2.752279	2.752356	77
566	2.752816	2.752893	2.752970	2.753047	2.753123	77
567	2.753583	2.753660	2.753736	2.753813	2.753889	77
568	2.754348	2.754425	2.754501	2.754578	2.754654	76
569	2.755112	2.755189	2.755265	2.755341	2.755417	76
570	2.755875	2.755951	2.756027	2.756103	2.756180	76
571	2.756636	2.756712	2.756788	2.756864	2.756940	76
572	2.757396	2.757472	2.757548	2.757624	2.757700	76

from 1 to 10000.

(405)

Diff.	Num.	5	6	7	8	9	Diff.
82	530	2.724685	2.724768	2.724849	2.724931	2.725011	82
82	531	2.725503	2.725585	2.725667	2.725748	2.725830	82
82	532	2.726320	2.726401	2.726483	2.726564	2.726645	82
81	533	2.727134	2.727216	2.727297	2.727379	2.727460	81
81	534	2.727948	2.728029	2.728110	2.728191	2.728273	81
81	535	2.728759	2.728841	2.728922	2.729003	2.729084	81
81	536	2.729570	2.729651	2.729732	2.729813	2.729893	81
81	537	2.730378	2.730459	2.730540	2.730621	2.730702	81
81	538	2.731186	2.731266	2.731347	2.731428	2.731508	81
81	539	2.731901	2.732072	2.732153	2.732233	2.732313	81
80	540	2.732796	2.732876	2.732956	2.733037	2.733117	80
80	541	2.733598	2.733679	2.733759	2.733839	2.733919	80
80	542	2.734400	2.734480	2.734560	2.734640	2.734720	80
80	543	2.735200	2.735279	2.735359	2.735439	2.735519	80
80	544	2.735998	2.736078	2.736157	2.736237	2.736317	80
80	545	2.736795	2.736874	2.736954	2.737034	2.737113	80
79	546	2.737590	2.737670	2.737749	2.737829	2.737908	79
79	547	2.738384	2.738463	2.738543	2.738622	2.738701	79
79	548	2.739177	2.739256	2.739335	2.739414	2.739493	79
79	549	2.739958	2.740047	2.740126	2.740205	2.740284	79
79	550	2.740757	2.740836	2.740915	2.740994	2.741073	79
79	551	2.741546	2.741624	2.741703	2.741782	2.741860	79
79	552	2.742332	2.742411	2.742489	2.742568	2.742647	79
78	553	2.743118	2.743196	2.743275	2.743353	2.743431	78
78	554	2.743902	2.743980	2.744058	2.744136	2.744215	78
78	555	2.744684	2.744762	2.744840	2.744919	2.744997	78
78	556	2.745465	2.745543	2.745621	2.745699	2.745777	78
78	557	2.746245	2.746323	2.746401	2.746479	2.746556	78
78	558	2.747023	2.747101	2.747179	2.747256	2.747334	78
78	559	2.747800	2.747878	2.747955	2.748033	2.748110	78
77	560	2.748576	2.748653	2.748731	2.748808	2.748885	77
77	561	2.749350	2.749427	2.749504	2.749582	2.749659	77
77	562	2.750123	2.750200	2.750277	2.750354	2.750431	77
77	563	2.750894	2.750971	2.751048	2.751125	2.751202	77
77	564	2.751664	2.751741	2.751818	2.751895	2.751972	77
77	565	2.752433	2.752509	2.752586	2.752663	2.752740	77
77	566	2.753200	2.753277	2.753353	2.753430	2.753506	77
77	567	2.753966	2.754042	2.754119	2.754195	2.754272	77
76	568	2.754730	2.754807	2.754883	2.754960	2.755036	76
76	569	2.755494	2.755570	2.755646	2.755722	2.755799	76
76	570	2.756256	2.756332	2.756408	2.756484	2.756560	76
76	571	2.757016	2.757092	2.757168	2.757244	2.757320	76
76	572	2.757775	2.757851	2.757927	2.758003	2.758079	76

Num.	0	1	2	3	4	Diff.
573	2.758155	2.758230	2.758306	2.758382	2.758458	76
574	2.758912	2.758988	2.759063	2.759139	2.759214	76
575	2.759668	2.759743	2.759819	2.759894	2.759970	75
576	2.760422	2.760498	2.760573	2.760649	2.760724	75
577	2.761176	2.761251	2.761326	2.761402	2.761477	75
578	2.761928	2.762003	2.762078	2.762153	2.762228	75
579	2.762679	2.762754	2.762829	2.762904	2.762978	75
570	2.763428	2.763503	2.763578	2.763653	2.763727	75
581	2.764176	2.764251	2.764326	2.764400	2.764475	75
582	2.764923	2.764998	2.765072	2.765147	2.765221	75
583	2.765669	2.765743	2.765818	2.765892	2.765966	74
584	2.766413	2.766487	2.766562	2.766636	2.766710	74
585	2.767156	2.767230	2.767304	2.767379	2.767453	74
586	2.767898	2.767972	2.768046	2.768120	2.768194	74
587	2.768639	2.768712	2.768786	2.768860	2.768934	74
588	2.769377	2.769451	2.769525	2.769599	2.769673	74
589	2.770135	2.770189	2.770263	2.770336	2.770410	74
590	2.770852	2.770926	2.770999	2.771073	2.771146	74
591	2.771587	2.771661	2.771734	2.771808	2.771881	73
592	2.772322	2.772395	2.772468	2.772542	2.772615	73
593	2.773055	2.773128	2.773201	2.773274	2.773348	73
594	2.773786	2.773860	2.773933	2.774006	2.774079	73
595	2.774517	2.774590	2.774663	2.774736	2.774809	73
596	2.775246	2.775319	2.775392	2.775465	2.775538	73
597	2.775974	2.776047	2.776120	2.776193	2.776265	73
598	2.776701	2.776774	2.776846	2.776919	2.776992	73
599	2.777427	2.777499	2.777572	2.777644	2.777717	72
600	2.778151	2.778224	2.778296	2.778368	2.778441	72
601	2.778874	2.778947	2.779019	2.779091	2.779163	72
602	2.779596	2.779669	2.779741	2.779813	2.779885	72
603	2.780317	2.780389	2.780461	2.780533	2.780605	72
604	2.781037	2.781109	2.781181	2.781253	2.781324	72
605	2.781755	2.781827	2.781899	2.781971	2.782042	72
606	2.782473	2.782544	2.782616	2.782688	2.782759	72
607	2.783189	2.783260	2.783332	2.783403	2.783475	71
608	2.783904	2.783975	2.784046	2.784118	2.784189	71
609	2.784617	2.784689	2.784760	2.784831	2.784902	71
610	2.785330	2.785401	2.785472	2.785543	2.785615	71
611	2.786041	2.786112	2.786183	2.786254	2.786325	71
612	2.786751	2.786822	2.786893	2.786964	2.787035	71
613	2.787460	2.787531	2.787602	2.787673	2.787744	71
614	2.788168	2.788239	2.788310	2.788381	2.788451	71
615	2.788875	2.788946	2.789016	2.789087	2.789157	71

from 1 to 10000.

(407)

Diff.	Num.	5	6	7	8	9	Diff.
76	573	2.758533	2.758609	2.758685	2.758761	2.758836	76
76	574	2.759290	2.759366	2.759441	2.759517	2.759592	76
75	575	2.750045	2.760121	2.760196	2.760272	2.760347	75
75	576	2.760799	2.760875	2.760950	2.761025	2.761101	75
75	577	2.761552	2.761627	2.761702	2.761778	2.761853	75
75	578	2.762303	2.762378	2.762453	2.762529	2.762604	75
75	579	2.763053	2.763128	2.763203	2.763278	2.763353	75
75	580	2.763802	2.763877	2.763952	2.764027	2.764101	75
75	581	2.764550	2.764624	2.764699	2.764774	2.764848	75
75	582	2.765296	2.765370	2.765445	2.765520	2.765594	75
74	583	2.766041	2.766115	2.766190	2.766264	2.766338	74
74	584	2.766785	2.766859	2.766933	2.767007	2.767082	74
74	585	2.767527	2.767601	2.767675	2.767749	2.767823	74
74	586	2.768268	2.768342	2.768416	2.768490	2.768564	74
74	587	2.769008	2.769082	2.769156	2.769230	2.769303	74
74	588	2.769746	2.769820	2.769894	2.769968	2.770042	74
74	589	2.770484	2.770557	2.770631	2.770705	2.770778	74
74	590	2.771220	2.771293	2.771367	2.771440	2.771514	74
73	591	2.771955	2.772028	2.772102	2.772175	2.772248	73
73	592	2.772688	2.772762	2.772835	2.772908	2.772981	73
73	593	2.773421	2.773494	2.773567	2.773640	2.773713	73
73	594	2.774152	2.774225	2.774298	2.774371	2.774444	73
73	595	2.774882	2.774955	2.775028	2.775100	2.775173	73
73	596	2.775610	2.775683	2.775756	2.775829	2.775902	73
73	597	2.776338	2.776411	2.776483	2.776556	2.776629	73
73	598	2.777064	2.777137	2.777209	2.777282	2.777354	73
72	599	2.777789	2.777862	2.777934	2.778006	2.778079	72
72	600	2.778513	2.778585	2.778658	2.778730	2.778802	72
72	601	2.779236	2.779308	2.779380	2.779452	2.779524	72
72	602	2.779957	2.780029	2.780101	2.780173	2.780245	72
72	603	2.780677	2.780749	2.780821	2.780893	2.780965	72
72	604	2.781396	2.781468	2.781540	2.781612	2.781684	72
72	605	2.782114	2.782186	2.782258	2.782329	2.782401	72
72	606	2.782831	2.782902	2.782974	2.783046	2.783117	71
71	607	2.783546	2.783618	2.783689	2.783761	2.783832	71
71	608	2.784261	2.784332	2.784403	2.784475	2.784546	71
71	609	2.784974	2.785045	2.785116	2.785187	2.785259	71
71	610	2.785685	2.785757	2.785828	2.785899	2.785970	71
71	611	2.786396	2.786467	2.786538	2.786609	2.786680	71
71	612	2.787106	2.787177	2.787248	2.787319	2.787390	71
71	613	2.787815	2.787885	2.787956	2.788027	2.788098	71
71	614	2.788522	2.788593	2.788663	2.788734	2.788804	71
71	615	2.789228	2.789299	2.789369	2.789440	2.789510	71

Num.	0	1	2	3	4	Diff.
616	2.789581	2.789651	2.789722	2.789792	2.789862	70
617	2.790285	2.790356	2.790426	2.790496	2.790567	70
618	2.790988	2.791059	2.791129	2.791199	2.791269	70
619	2.791691	2.791761	2.791831	2.791901	2.791971	70
620	2.792392	2.792462	2.792532	2.792602	2.792672	70
621	2.793092	2.793162	2.793231	2.793301	2.793371	70
622	2.793790	2.793860	2.793930	2.794000	2.794070	70
623	2.794488	2.794558	2.794627	2.794697	2.794767	70
624	2.795185	2.795254	2.795324	2.795393	2.795463	70
625	2.795880	2.795949	2.796019	2.796088	2.796158	69
626	2.796574	2.796644	2.796713	2.796782	2.796852	69
627	2.797268	2.797337	2.797406	2.797475	2.797545	69
628	2.797960	2.798029	2.798098	2.798167	2.798236	69
629	2.798651	2.798720	2.798789	2.798858	2.798927	69
630	2.799341	2.799409	2.799478	2.799547	2.799616	69
631	2.800029	2.800098	2.800166	2.800236	2.800305	69
632	2.800717	2.800786	2.800854	2.800923	2.800992	69
633	2.801404	2.801472	2.801541	2.801609	2.801678	69
634	2.802089	2.802158	2.802226	2.802295	2.802363	68
635	2.802774	2.802842	2.802910	2.802979	2.803047	68
636	2.803457	2.803525	2.803594	2.803662	2.803730	68
637	2.804139	2.804208	2.804276	2.804344	2.804412	68
638	2.804821	2.804889	2.804957	2.805025	2.805093	68
639	2.805501	2.805569	2.805637	2.805705	2.805773	68
640	2.806180	2.806248	2.806316	2.806384	2.806451	68
641	2.806858	2.806926	2.806994	2.807061	2.807129	68
642	2.807535	2.807603	2.807670	2.807738	2.807806	68
643	2.808211	2.808279	2.808346	2.808414	2.808481	67
644	2.808886	2.808953	2.809021	2.809088	2.809155	67
645	2.809560	2.809627	2.809694	2.809762	2.809829	67
646	2.810232	2.810300	2.810367	2.810434	2.810501	67
647	2.810904	2.810971	2.811038	2.811106	2.811173	67
648	2.811575	2.811642	2.811709	2.811776	2.811843	67
649	2.812245	2.812312	2.812378	2.812445	2.812512	67
650	2.812913	2.812980	2.813047	2.813114	2.813180	67
651	2.813581	2.813648	2.813714	2.813781	2.813848	67
652	2.814248	2.814314	2.814381	2.814447	2.814514	67
653	2.814913	2.814980	2.815046	2.815113	2.815179	66
654	2.815578	2.815644	2.815710	2.815777	2.815843	66
655	2.816241	2.816308	2.816374	2.816440	2.816506	66
656	2.816904	2.816970	2.817036	2.817102	2.817169	66
657	2.817565	2.817631	2.817698	2.817764	2.817830	66
658	2.818226	2.818292	2.818358	2.818424	2.818490	66

Num.	5	6	7	8	9	Diff.
616	2.789933	2.790003	2.790074	2.790144	2.790215	70
617	2.790032	2.790107	2.790178	2.790248	2.790318	70
618	2.791340	2.791410	2.791480	2.791550	2.791620	70
619	2.792041	2.792111	2.792181	2.792252	2.792322	70
620	2.792747	2.792812	2.792882	2.792952	2.793022	70
621	2.793441	2.793511	2.793581	2.793651	2.793721	70
622	2.794139	2.794209	2.794279	2.794349	2.794418	70
623	2.794836	2.794906	2.794976	2.795045	2.795115	70
624	2.795531	2.795602	2.795671	2.795741	2.795810	70
625	2.796227	2.796297	2.796366	2.796436	2.796505	69
626	2.796921	2.796990	2.797060	2.797129	2.797198	69
627	2.797614	2.797683	2.797752	2.797821	2.797890	69
628	2.798305	2.798374	2.798443	2.798512	2.798582	69
629	2.798996	2.799065	2.799134	2.799203	2.799272	69
630	2.799685	2.799754	2.799823	2.799892	2.799960	69
631	2.800373	2.800442	2.800511	2.800580	2.800648	69
632	2.801060	2.801129	2.801198	2.801267	2.801335	69
633	2.801747	2.801815	2.801884	2.801952	2.802021	69
634	2.802432	2.802500	2.802568	2.802637	2.802705	68
635	2.803116	2.803184	2.803252	2.803321	2.803389	68
636	2.803798	2.803867	2.803935	2.804003	2.804071	68
637	2.804480	2.804548	2.804616	2.804685	2.804753	68
638	2.805161	2.805229	2.805297	2.805365	2.805433	68
639	2.805840	2.805908	2.805976	2.806044	2.806112	68
640	2.806519	2.806587	2.806655	2.806723	2.806790	68
641	2.807197	2.807264	2.807332	2.807400	2.807467	68
642	2.807873	2.807941	2.808008	2.808076	2.808143	68
643	2.808548	2.808616	2.808683	2.808751	2.808818	67
644	2.809223	2.809290	2.809358	2.809425	2.809492	67
645	2.809896	2.809963	2.810031	2.810098	2.810165	67
646	2.810568	2.810636	2.810703	2.810770	2.810837	67
647	2.811240	2.811307	2.811374	2.811441	2.811508	67
648	2.811910	2.811977	2.812044	2.812111	2.812178	67
649	2.812579	2.812646	2.812713	2.812780	2.812846	67
650	2.813247	2.813314	2.813381	2.813447	2.813514	67
651	2.813914	2.813981	2.814048	2.814114	2.814181	67
652	2.814580	2.814647	2.814714	2.814780	2.814847	67
653	2.815246	2.815312	2.815378	2.815445	2.815511	66
654	2.815910	2.815976	2.816042	2.816109	2.816175	66
655	2.816573	2.816639	2.816705	2.816771	2.816838	66
656	2.817235	2.817301	2.817367	2.817433	2.817499	66
657	2.817896	2.817962	2.818028	2.818094	2.818160	66
658	2.818556	2.818622	2.818688	2.818754	2.818819	66

Num.	0	1	2	3	4	Diff.
659	2.818885	2.818951	2.819017	2.819083	2.819149	66
660	2.819544	2.819610	2.819675	2.819741	2.819807	66
661	2.820201	2.820267	2.820333	2.820398	2.820464	66
662	2.820858	2.820924	2.820989	2.821055	2.821120	66
663	1.821513	2.821579	2.821644	2.821710	2.821775	65
664	2.822168	2.822233	2.822299	2.822364	2.822430	65
665	2.822822	2.822887	2.822952	2.823017	2.823083	65
666	2.823474	2.823539	2.823605	2.823670	2.823735	65
667	2.824126	2.824191	2.824256	2.824321	2.824386	65
668	2.824776	2.824841	2.824906	2.824971	2.825036	65
669	2.825426	2.825491	2.825556	2.825621	2.825686	65
670	2.826075	2.826140	2.826204	2.826269	2.826334	65
671	2.826722	2.826787	2.826852	2.826917	2.826981	65
672	2.827369	2.827434	2.827498	2.827563	2.827628	65
673	2.828015	2.828080	2.828144	2.828209	2.828273	64
674	2.828660	2.828724	2.828789	2.828853	2.828918	64
675	2.829304	2.829368	2.829432	2.829497	2.829561	64
676	2.829947	2.830011	2.830075	2.830139	2.830204	64
677	2.830589	2.830653	2.830717	2.830781	2.830845	64
678	2.831230	2.831294	2.831358	2.831422	2.831486	64
679	2.831870	2.831934	2.831998	2.832062	2.832125	64
680	2.832509	2.832573	2.832637	2.832700	2.832764	64
681	2.833147	2.833211	2.833275	2.833338	2.833402	64
682	2.833784	2.833848	2.833912	2.833975	2.834039	64
683	2.834421	2.834484	2.834548	2.834611	2.834675	64
684	2.835056	2.835120	2.835183	2.835246	2.835310	63
685	2.835691	2.835754	2.835817	2.835881	2.835944	63
686	2.836324	2.836387	2.836451	2.836514	2.836577	63
687	2.836957	2.837020	2.837083	2.837146	2.837209	63
688	2.837588	2.837652	2.837715	2.837778	2.837841	63
689	2.838219	2.838282	2.838345	2.838408	2.838471	63
690	2.838849	2.838912	2.838975	2.839038	2.839101	63
691	2.839478	2.839541	2.839604	2.839667	2.839729	63
692	2.840106	2.840169	2.840232	2.840294	2.840357	63
693	2.840733	2.840796	2.840859	2.840921	2.840984	63
694	2.841359	2.841422	2.841485	2.841547	2.841610	63
695	2.841985	2.842047	2.842110	2.842172	2.842235	62
696	2.842609	2.842672	2.842734	2.842796	2.842859	62
697	2.843233	2.843295	2.843357	2.843420	2.843482	62
698	2.843855	2.843918	2.843980	2.844042	2.844104	62
699	2.844477	2.844539	2.844601	2.844663	2.844726	62
700	2.845098	2.845160	2.845222	2.845284	2.845347	62
701	2.845718	2.845780	2.845840	2.845904	2.845966	62

from 1 to 10000.

(411)

Diff.	Num.	5	6	7	8	9	Diff
66	659	2.819215	2.819281	2.816346	2.819412	2.819478	66
66	660	2.819373	2.819939	2.820004	2.820070	2.820136	66
66	661	2.820530	2.820595	2.820661	2.820727	2.820792	66
66	662	2.821186	2.821251	2.821317	2.821382	2.821448	66
65	663	2.821841	2.821906	2.821972	2.822037	2.822103	65
65	664	2.822495	2.822560	2.822626	2.822691	2.822756	65
65	665	2.823148	2.823213	2.823279	2.823344	2.823409	65
65	666	2.823800	2.823865	2.823930	2.823996	2.824061	65
65	667	2.824451	2.824516	2.824581	2.824646	2.824711	65
65	668	2.825101	2.825166	2.825231	2.825296	2.825361	65
65	669	2.825751	2.825815	2.825880	2.825945	2.826010	65
65	670	2.826399	2.826464	2.826528	2.826593	2.826658	65
65	671	2.827046	2.827111	2.827175	2.827240	2.827305	65
65	672	2.827692	2.827757	2.827821	2.827886	2.827950	65
64	673	2.828338	2.828402	2.828466	2.828531	2.828595	64
64	674	2.828982	2.829046	2.829111	2.829175	2.829239	64
64	675	2.829625	2.829690	2.829754	2.829818	2.829882	64
64	676	2.830268	2.830332	2.830396	2.830460	2.830524	64
64	677	2.830909	2.830973	2.831037	2.831102	2.831166	64
64	678	2.831550	2.831614	2.831678	2.831742	2.831806	64
64	679	2.832189	2.832253	2.832317	2.832381	2.832445	64
64	680	2.832828	2.832892	2.832956	2.833019	2.833083	64
64	681	2.833466	2.833530	2.833593	2.833657	2.833721	64
64	682	2.834103	2.834166	2.834230	2.834293	2.834357	64
64	683	2.834738	2.834802	2.834866	2.834929	2.834993	64
63	684	2.835373	2.835437	2.835500	2.835564	2.835627	63
63	685	2.836007	2.836071	2.836134	2.836197	2.836261	63
63	686	2.836640	2.836704	2.836767	2.836830	2.836893	63
63	687	2.837273	2.837336	2.837399	2.837462	2.837525	63
63	688	2.837904	2.837967	2.838030	2.838093	2.838156	63
63	689	2.838534	2.838597	2.838660	2.838723	2.838786	63
63	690	2.839164	2.839227	2.839280	2.839342	2.839405	63
63	691	2.839792	2.839855	2.839918	2.839981	2.840043	63
63	692	2.840420	2.840482	2.840545	2.840608	2.840671	63
63	693	2.841046	2.841109	2.841172	2.841234	2.841297	63
63	694	2.841672	2.841735	2.841797	2.841860	2.841922	63
62	695	2.842297	2.842360	2.842422	2.842484	2.842547	62
62	696	2.842921	2.842983	2.843046	2.843108	2.843170	62
62	697	2.843544	2.843606	2.843669	2.843731	2.843793	62
62	698	2.844166	2.844229	2.844291	2.844353	2.844415	62
62	699	2.844788	2.844850	2.844912	2.844974	2.845036	62
62	700	2.845408	2.845470	2.845532	2.845594	2.845656	62
62	701	2.846028	2.846090	2.846151	2.846213	2.846275	62

Num.	0	1	2	3	4	Diff.
702	2.846337	2.846399	2.846461	2.846523	2.846584	62
703	2.846955	2.847017	2.847079	2.847141	2.847202	62
704	2.847573	2.847634	2.847696	2.847758	2.847819	62
705	2.848189	2.848251	2.848312	2.848374	2.848435	62
706	2.848805	2.848866	2.848928	2.848989	2.849051	61
707	2.849419	2.849481	2.849542	2.849604	2.849665	61
708	2.850033	2.850095	2.850156	2.850217	2.850279	61
709	2.850646	2.850707	2.850769	2.850830	2.850891	61
710	2.851258	2.851319	2.851381	2.851442	2.851503	61
711	2.851870	2.851931	2.851992	2.852053	2.852114	61
712	2.852480	2.852541	2.852602	2.852663	2.852724	61
713	2.853089	2.853150	2.853211	2.853272	2.853333	61
714	2.853698	2.853759	2.853820	2.853881	2.853941	61
715	2.854306	2.854367	2.854427	2.854488	2.854549	61
716	2.854913	2.854974	2.855034	2.855095	2.855156	61
717	2.855519	2.855580	2.855640	2.855701	2.855761	61
718	2.856124	2.856185	2.856245	2.856306	2.856366	60
719	2.856729	2.856789	2.856850	2.856910	2.856970	60
720	2.857332	2.857393	2.857453	2.857513	2.857574	60
721	2.857935	2.857995	2.858056	2.858116	2.858176	60
722	2.858537	2.858597	2.858657	2.858718	2.858778	60
723	2.859138	2.859198	2.859258	2.859318	2.859378	60
724	2.859739	2.859798	2.859858	2.859918	2.859978	60
725	2.860338	2.860398	2.860458	2.860518	2.860578	60
726	2.860937	2.860996	2.861056	2.861116	2.861176	60
727	2.861534	2.861594	2.861654	2.861714	2.861773	60
728	2.862131	2.862191	2.862251	2.862310	2.862370	60
729	2.862727	2.862787	2.862847	2.862906	2.862966	60
730	2.863323	2.863382	2.863442	2.863501	2.863561	59
731	2.863917	2.863977	2.864036	2.864096	2.864155	59
732	2.864511	2.864570	2.864630	2.864689	2.864748	59
733	2.865104	2.865162	2.865222	2.865282	2.865341	59
734	2.865696	2.865755	2.865814	2.865873	2.865933	59
735	2.866268	2.866326	2.866385	2.866445	2.866504	59
736	2.866878	2.866937	2.866996	2.867055	2.867114	59
737	2.867467	2.867526	2.867585	2.867644	2.867703	59
738	2.868056	2.868115	2.868174	2.868233	2.868292	59
739	2.868644	2.868703	2.868762	2.868821	2.868879	59
740	2.869232	2.869290	2.869349	2.869408	2.869466	59
741	2.869818	2.869877	2.869935	2.869994	2.870053	59
742	2.870404	2.870462	2.870521	2.870579	2.870638	58
743	2.870989	2.871047	2.871106	2.871164	2.871223	58
744	2.871573	2.871631	2.871690	2.871748	2.871806	58

from 1 to 10000.

(413)

Diff.	Num.	5	6	7	8	9	Diff.
62	702	2.846646	2.846708	2.846770	2.846832	2.846893	62
62	703	2.847264	2.847326	2.847388	2.847449	2.847511	62
62	704	2.847881	2.847943	2.848004	2.848066	2.848127	62
62	705	2.848497	2.848559	2.848620	2.848682	2.848743	62
61	706	2.849112	2.849174	2.849235	2.849296	2.849358	61
61	707	2.849725	2.849788	2.849849	2.849911	2.849972	61
61	708	2.850340	2.850401	2.850462	2.850524	2.850585	61
61	709	2.850952	2.851014	2.851075	2.851136	2.851197	61
61	710	2.851564	2.851625	2.851686	2.851747	2.851808	61
61	711	2.852175	2.852236	2.852297	2.852358	2.852419	61
61	712	2.852785	2.852846	2.852907	2.852968	2.853029	61
61	713	2.853394	2.853455	2.853516	2.853576	2.853637	61
61	714	2.854002	2.854063	2.854124	2.854184	2.854245	61
61	715	2.854610	2.854670	2.854731	2.854792	2.854852	61
61	716	2.855216	2.855277	2.855337	2.855398	2.855459	61
61	717	2.855822	2.855882	2.855943	2.856003	2.856064	61
60	718	2.856427	2.856487	2.856548	2.856608	2.856668	60
60	719	2.857031	2.857091	2.857151	2.857212	2.857272	60
60	720	2.857634	2.857694	2.857754	2.857815	2.857875	60
60	721	2.858236	2.858296	2.858357	2.858417	2.858477	60
60	722	2.858838	2.858898	2.858958	2.859018	2.859078	60
60	723	2.859438	2.859499	2.859559	2.859619	2.859679	60
60	724	2.860038	2.860098	2.860158	2.860218	2.860278	60
60	725	2.860637	2.860697	2.860757	2.860817	2.860877	60
60	726	2.861236	2.861295	2.861355	2.861415	2.861475	60
60	727	2.861833	2.861893	2.861952	2.862012	2.862072	60
60	728	2.862430	2.862489	2.862549	2.862608	2.862668	60
60	729	2.863025	2.863085	2.863144	2.863204	2.863263	60
59	730	2.863620	2.863680	2.863739	2.863798	2.863858	59
59	731	2.864214	2.864274	2.864333	2.864392	2.864452	59
59	732	2.864808	2.864867	2.864926	2.864985	2.865045	59
59	733	2.865400	2.865459	2.865518	2.865578	2.865637	59
59	734	2.865992	2.866051	2.866110	2.866169	2.866228	59
59	735	2.866583	2.866642	2.866701	2.866760	2.866819	59
59	736	2.867173	2.867232	2.867291	2.867350	2.867409	59
59	737	2.867762	2.867821	2.867880	2.867939	2.867997	59
59	738	2.868350	2.868409	2.868468	2.868527	2.868586	59
59	739	2.868938	2.868997	2.869056	2.869114	2.869173	59
59	740	2.869525	2.869584	2.869642	2.869701	2.869760	59
58	741	2.870111	2.870170	2.870228	2.870287	2.870345	59
58	742	2.870696	2.870755	2.870813	2.870872	2.870930	58
58	743	2.871281	2.871339	2.871398	2.871456	2.871515	58
58	744	2.871865	2.871923	2.871981	2.872040	2.872098	58

Num.	0	1	2	3	4	Diff.
745	2.872156	2.872215	2.872273	2.872331	2.872389	58
746	2.872739	2.872797	2.872855	2.872913	2.872972	58
747	2.873321	2.873379	2.873437	2.873495	2.873553	58
748	2.873902	2.873960	2.874018	2.874076	2.874134	58
749	2.874482	2.874540	2.874598	2.874656	2.874714	58
750	2.875061	2.875119	2.875177	2.875235	2.875293	58
751	2.875640	2.875698	2.875756	2.875813	2.875871	58
752	2.876218	2.876276	2.876333	2.876391	2.876449	58
753	2.876795	2.876853	2.876910	2.876968	2.877026	58
754	2.877371	2.877429	2.877486	2.877544	2.877602	58
755	2.877947	2.878004	2.878062	2.878119	2.878177	57
756	2.878522	2.878579	2.878637	2.878694	2.878751	57
757	2.879096	2.879153	2.879211	2.879268	2.879325	57
758	2.879669	2.879726	2.879784	2.879841	2.879898	57
759	2.880242	2.880299	2.880356	2.880413	2.880471	57
760	2.880814	2.880871	2.880928	2.880985	2.881042	57
761	2.881385	2.881442	2.881499	2.881556	2.881613	57
762	2.881955	2.882012	2.882069	2.882126	2.882183	57
763	2.882524	2.882581	2.882638	2.882695	2.882752	57
764	2.883093	2.883150	2.883207	2.883264	2.883321	57
765	2.883661	2.883718	2.883775	2.883832	2.883889	57
766	2.884229	2.884285	2.884342	2.884399	2.884455	57
767	2.884795	2.884852	2.884909	2.884965	2.885022	57
768	2.885361	2.885418	2.885474	2.885531	2.885587	57
769	2.885926	2.885983	2.886039	2.886096	2.886152	56
770	2.886491	2.886547	2.886603	2.886660	2.886716	56
771	2.887054	2.887111	2.887167	2.887223	2.887280	56
772	2.887617	2.887673	2.887730	2.887786	2.887842	56
773	2.888179	2.888236	2.888292	2.888348	2.888404	56
774	2.888741	2.888797	2.888853	2.888909	2.888965	56
775	2.889302	2.889358	2.889414	2.889470	2.889526	56
776	2.889862	2.889918	2.889974	2.890030	2.890086	56
777	2.890421	2.890477	2.890533	2.890589	2.890644	56
778	2.890980	2.891035	2.891091	2.891147	2.891203	56
779	2.891537	2.891593	2.891649	2.891705	2.891760	56
780	2.892095	2.892150	2.892206	2.892262	2.892317	56
781	2.892651	2.892707	2.892762	2.892818	2.892873	56
782	2.893207	2.893262	2.893318	2.893373	2.893429	56
783	2.893762	2.893817	2.893873	2.893928	2.893984	55
784	2.894316	2.894371	2.894427	2.894482	2.894538	55
785	2.894870	2.894925	2.894980	2.895036	2.895091	55
786	2.895422	2.895478	2.895533	2.895588	2.895643	55
787	2.895975	2.896030	2.896085	2.896140	2.896195	55

from 1 to 10000.

(415)

Diff.	Num.	5	6	7	8	9	Diff.
58	745	2.872448	2.872506	2.872564	2.872622	2.872681	58
58	746	2.873030	2.873088	2.873146	2.873204	2.873260	58
58	747	2.873611	2.873669	2.873727	2.873785	2.873843	58
58	748	2.874192	2.874250	2.874308	2.874366	2.874424	58
58	749	2.874772	2.874830	2.874887	2.874945	2.875003	58
58	750	2.875351	2.875409	2.875466	2.875524	2.875582	58
58	751	2.875929	2.875987	2.876044	2.876102	2.876160	58
58	752	2.876506	2.876564	2.876622	2.876680	2.876737	58
58	753	2.877083	2.877141	2.877198	2.877256	2.877314	58
58	754	2.877659	2.877717	2.877774	2.877832	2.877889	58
57	755	2.878234	2.878292	2.878349	2.878407	2.878464	57
57	756	2.878809	2.878866	2.878922	2.878981	2.879030	57
57	757	2.879383	2.879440	2.879497	2.879555	2.879612	57
57	758	2.879956	2.880013	2.880070	2.880127	2.880185	57
57	759	2.880528	2.880585	2.880642	2.880699	2.880756	57
57	760	2.881099	2.881156	2.881213	2.881270	2.881328	57
57	761	2.881670	2.881727	2.881784	2.881841	2.881898	57
57	762	2.882240	2.882297	2.882354	2.882411	2.882468	57
57	763	2.882809	2.882866	2.882923	2.882980	2.883036	57
57	764	2.883377	2.883434	2.883491	2.883548	2.883605	57
57	765	2.883945	2.884002	2.884059	2.884115	2.884172	57
57	766	2.884512	2.884569	2.884625	2.884682	2.884739	57
57	767	2.885078	2.885135	2.885191	2.885248	2.885305	57
57	768	2.885644	2.885700	2.885757	2.885813	2.885870	57
56	769	2.886209	2.886265	2.886321	2.886378	2.886434	56
56	770	2.886773	2.886829	2.886885	2.886942	2.886998	56
56	771	2.887336	2.887392	2.887448	2.887505	2.887561	56
56	772	2.887898	2.887955	2.888011	2.888067	2.888123	56
56	773	2.888460	2.888516	2.888573	2.888629	2.888685	56
56	774	2.889021	2.889077	2.889133	2.889190	2.889246	56
56	775	2.889582	2.889638	2.889694	2.889750	2.889806	56
56	776	2.890141	2.890197	2.890253	2.890309	2.890365	56
56	777	2.890700	2.890756	2.890812	2.890868	2.890924	56
56	778	2.891259	2.891314	2.891370	2.891426	2.891482	56
56	779	2.891816	2.891872	2.891927	2.891983	2.892039	56
56	780	2.892373	2.892428	2.892484	2.892540	2.892595	56
56	781	2.892929	2.892985	2.893040	2.893096	2.893151	56
56	782	2.893484	2.893540	2.893595	2.893651	2.893706	56
55	783	2.894039	2.894094	2.894150	2.894205	2.894261	55
55	784	2.894593	2.894648	2.894704	2.894759	2.894814	55
55	785	2.895146	2.895201	2.895257	2.895312	2.895367	55
55	786	2.895699	2.895754	2.895809	2.895864	2.895919	55
55	787	2.896251	2.896306	2.896361	2.896416	2.896471	55

Num.	0	1	2	3	4	Diff.
788	2.896526	2.896581	2.896636	2.896691	2.896747	55
789	2.897077	2.897132	2.897187	2.897242	2.897297	55
790	2.897627	2.897682	2.897737	2.897792	2.897847	55
791	2.898176	2.898231	2.898286	2.898341	2.898396	55
792	2.898723	2.898780	2.898835	2.898890	2.898944	55
793	2.899273	2.899328	2.899383	2.899437	2.899492	55
794	2.899820	2.899875	2.899930	2.899985	2.900039	55
795	2.900367	2.900422	2.900476	2.900531	2.900586	55
796	2.900913	2.900968	2.901022	2.901077	2.901131	55
797	2.901458	2.901513	2.901567	2.901622	2.901676	54
798	2.902003	2.902057	2.902112	2.902166	2.902220	54
799	2.902547	2.902601	2.902655	2.902710	2.902764	54
800	2.903090	2.903144	2.903198	2.903253	2.903307	54
801	2.903632	2.903687	2.903741	2.903795	2.903849	54
802	2.904174	2.904228	2.904283	2.904337	2.904391	54
803	2.904715	2.904770	2.904824	2.904878	2.904932	54
804	2.905256	2.905310	2.905364	2.905418	2.905473	54
805	2.905796	2.905850	2.905904	2.905958	2.906012	54
806	2.906335	2.906389	2.906443	2.906497	2.906550	54
807	2.906873	2.906927	2.906981	2.907035	2.907089	54
808	2.907411	2.907465	2.907519	2.907573	2.907626	54
809	2.907948	2.908002	2.908056	2.908109	2.908163	54
810	2.908485	2.908539	2.908592	2.908646	2.908699	54
811	2.909021	2.909074	2.909128	2.909181	2.909235	53
812	2.909556	2.909609	2.909663	2.909716	2.909770	53
813	2.910090	2.910144	2.910197	2.910251	2.910304	53
814	2.910624	2.910678	2.910731	2.910784	2.910838	53
815	2.911158	2.911211	2.911264	2.911317	2.911371	53
816	2.911690	2.911743	2.911797	2.911850	2.911903	53
817	2.912222	2.912275	2.912328	2.912381	2.912435	53
818	2.912753	2.912806	2.912859	2.912912	2.912966	53
819	2.913284	2.913337	2.913390	2.913443	2.913496	53
820	2.913814	2.913867	2.913920	2.913973	2.914026	53
821	2.914343	2.914396	2.914449	2.914502	2.914555	53
822	2.914872	2.914925	2.914977	2.915030	2.915083	53
823	2.915400	2.915453	2.915505	2.915558	2.915611	53
824	2.915927	2.915980	2.916033	2.916085	2.916138	53
825	2.916454	2.916507	2.916559	2.916612	2.916664	53
826	2.916980	2.917033	2.917085	2.917138	2.917190	53
827	2.917505	2.917558	2.917610	2.917663	2.917715	52
828	2.918030	2.918083	2.918135	2.918188	2.918240	52
829	2.918554	2.918607	2.918659	2.918712	2.918764	52
830	2.919078	2.919130	2.919183	2.919235	2.919287	52

from 1 to 10000.

(417)

Diff.	Num.	5	6	7	8	9	Diff.
55	788	2.896802	2.896857	2.896912	2.896967	2.897022	55
55	789	2.897352	2.897407	2.897462	2.897517	2.897572	55
55	790	2.897902	2.897957	2.898012	2.898067	2.898122	55
55	791	2.898451	2.898506	2.898561	2.898615	2.898670	55
55	792	2.898999	2.899054	2.899109	2.899164	2.899218	55
55	793	2.899547	2.899602	2.899656	2.899711	2.899769	55
55	794	2.900094	2.900149	2.900203	2.900258	2.900312	55
55	795	2.900640	2.900695	2.900749	2.900804	2.900858	55
55	796	2.901186	2.901240	2.901295	2.901349	2.901404	55
54	797	2.901731	2.901785	2.901840	2.901894	2.901948	54
54	798	2.902275	2.902329	2.902384	2.902438	2.902492	54
54	799	2.902818	2.902873	2.902927	2.902981	2.903036	54
54	800	2.903361	2.903416	2.903470	2.903524	2.903578	54
54	801	2.903903	2.903958	2.904012	2.904066	2.904120	54
54	802	2.904445	2.904499	2.904553	2.904607	2.904661	54
54	803	2.904986	2.905040	2.905094	2.905148	2.905202	54
54	804	2.905526	2.905580	2.905634	2.905688	2.905742	54
54	805	2.906065	2.906119	2.906173	2.906227	2.906281	54
54	806	2.906604	2.906658	2.906712	2.906766	2.906820	54
54	807	2.907142	2.907196	2.907250	2.907304	2.907358	54
54	808	2.907680	2.907734	2.907787	2.907841	2.907895	54
54	809	2.908217	2.908270	2.908324	2.908378	2.908431	54
54	810	2.908753	2.908807	2.908860	2.908914	2.908967	54
53	811	2.909288	2.909342	2.909395	2.909449	2.909502	54
53	812	2.909823	2.909877	2.909930	2.909984	2.910037	53
53	813	2.910358	2.910411	2.910464	2.910518	2.910571	53
53	814	2.910891	2.910944	2.910998	2.911051	2.911104	53
53	815	2.911424	2.911477	2.911530	2.911584	2.911637	53
53	816	2.911956	2.912009	2.912063	2.912116	2.912169	53
53	817	2.912488	2.912541	2.912594	2.912647	2.912700	53
53	818	2.913019	2.913072	2.913125	2.913178	2.913231	53
53	819	2.913549	2.913602	2.913655	2.913708	2.913761	53
53	820	2.914079	2.914131	2.914184	2.914237	2.914290	53
53	821	2.914608	2.914660	2.914713	2.914766	2.914819	53
53	822	2.915136	2.915189	2.915241	2.915294	2.915347	53
53	823	2.915664	2.915716	2.915769	2.915822	2.915874	53
53	824	2.916191	2.916243	2.916296	2.916349	2.916401	53
53	825	2.916717	2.916770	2.916822	2.916875	2.916927	53
53	826	2.917243	2.917295	2.917348	2.917400	2.917453	53
52	827	2.917768	2.917820	2.917873	2.917925	2.917978	52
52	828	2.918292	2.918345	2.918397	2.918450	2.918502	52
52	829	2.918816	2.918869	2.918921	2.918973	2.919026	52
52	830	2.919340	2.919392	2.919444	2.919496	2.919549	52

F f

Num.	0	1	2	3	4	Diff.
831	2.919601	2.919653	2.919705	2.919758	2.919810	52
832	2.920123	2.920175	2.920228	2.920280	2.920332	52
833	2.920645	2.920697	2.920749	2.920801	2.920853	52
834	2.921166	2.921218	2.921270	2.921322	2.921374	52
835	2.921685	2.921738	2.921790	2.921842	2.921894	52
836	2.922206	2.922258	2.922310	2.922362	2.922414	52
837	2.922725	2.922777	2.922829	2.922881	2.922933	52
838	2.923244	2.923296	2.923348	2.923399	2.923451	52
839	2.923762	2.923814	2.923865	2.923917	2.923969	52
840	2.924279	2.924331	2.924383	2.924434	2.924486	52
841	2.924790	2.924842	2.924894	2.924951	2.925002	52
842	2.925312	2.925364	2.925415	2.925467	2.925518	52
843	2.925828	2.925879	2.925931	2.925982	2.926034	51
844	2.926342	2.926394	2.926445	2.926497	2.926548	51
845	2.926857	2.926908	2.926959	2.927011	2.927062	51
846	2.927370	2.927422	2.927473	2.927524	2.927576	51
847	2.927883	2.927935	2.927986	2.928037	2.928088	51
848	2.928390	2.928447	2.928498	2.928549	2.928601	51
849	2.928908	2.928959	2.929010	2.929061	2.929112	51
850	2.929419	2.929470	2.929521	2.929572	2.929623	51
851	2.929920	2.929981	2.930032	2.930083	2.930134	51
852	2.930440	2.930491	2.930541	2.930592	2.930643	51
853	2.930949	2.931000	2.931051	2.931102	2.931153	51
854	2.931455	2.931509	2.931560	2.931610	2.931661	51
855	2.931966	2.932017	2.932068	2.932118	2.932169	51
856	2.932474	2.932524	2.932575	2.932626	2.932677	51
857	2.932981	2.933031	2.933082	2.933133	2.933183	51
858	2.933487	2.933538	2.933588	2.933639	2.933690	51
859	2.933993	2.934044	2.934094	2.934145	2.934195	51
860	2.934498	2.934549	2.934599	2.934650	2.934700	50
861	2.935003	2.935054	2.935104	2.935154	2.935205	50
862	2.935507	2.935558	2.935608	2.935658	2.935709	50
863	2.936011	2.936061	2.936111	2.936162	2.936212	50
864	2.936514	2.936564	2.936614	2.936664	2.936715	50
865	2.937016	2.937066	2.937116	2.937167	2.937217	50
866	2.937518	2.937568	2.937618	2.937668	2.937718	50
867	2.938019	2.938069	2.938119	2.938169	2.938219	50
868	2.938520	2.938570	2.938620	2.938670	2.938720	50
869	2.939020	2.939070	2.939120	2.939170	2.939220	50
870	2.939519	2.939569	2.939619	2.939669	2.939719	50
871	2.940018	2.940068	2.940118	2.940168	2.940218	50
872	2.940516	2.940566	2.940616	2.940660	2.940716	50
873	2.941014	2.941064	2.941114	2.941163	2.941213	50

from 1 to 10000.

(419)

Diff.	Num.	5	6	7	8	9	Diff.
52	831	2.919862	2.919914	2.919967	2.920019	2.920071	52
52	832	2.920384	2.920436	2.920489	2.920541	2.920593	52
52	833	2.920906	2.920958	2.921010	2.921062	2.921114	52
52	834	2.921426	2.921478	2.921530	2.921582	2.921634	52
52	835	2.921946	2.921998	2.922050	2.922102	2.922154	52
52	836	2.922466	2.922518	2.922570	2.922622	2.922674	52
52	837	2.922985	2.923037	2.923088	2.923140	2.923192	52
52	838	2.923503	2.923555	2.923607	2.923658	2.923710	52
52	839	2.924021	2.924072	2.924124	2.924176	2.924228	52
52	840	2.924538	2.924589	2.924641	2.924693	2.924744	52
52	841	2.925054	2.925106	2.925157	2.925209	2.925260	52
52	842	2.925570	2.925621	2.925673	2.925724	2.925775	52
51	843	2.926085	2.926137	2.926188	2.926239	2.926291	52
51	844	2.926600	2.926651	2.926702	2.926754	2.926805	52
51	845	2.927114	2.927165	2.927216	2.927268	2.927319	52
51	846	2.927627	2.927678	2.927730	2.927781	2.927832	52
51	847	2.928140	2.928191	2.928242	2.928293	2.928345	52
51	848	2.928652	2.928703	2.928754	2.928805	2.928856	51
51	849	2.929163	2.929214	2.929266	2.929317	2.929368	51
51	850	2.929674	2.929725	2.929776	2.929827	2.929878	51
51	851	2.930185	2.930236	2.930287	2.930338	2.930389	51
51	852	2.930694	2.930745	2.930796	2.930847	2.930898	51
51	853	2.931203	2.931254	2.931305	2.931356	2.931407	51
51	854	2.931712	2.931763	2.931814	2.931864	2.931915	51
51	855	2.932220	2.932271	2.932321	2.932372	2.932423	51
51	856	2.932727	2.932778	2.932829	2.932879	2.932930	51
51	857	2.933234	2.933285	2.933335	2.933386	2.933437	51
51	858	2.933740	2.933791	2.933841	2.933892	2.933943	51
51	859	2.934246	2.934296	2.934347	2.934397	2.934448	51
50	860	2.934751	2.934801	2.934852	2.934902	2.935953	50
50	861	2.935255	2.935306	2.935356	2.935406	2.935457	50
50	862	2.935759	2.935809	2.935860	2.935910	2.935960	50
50	863	2.936262	2.936313	2.936363	2.936413	2.936463	50
50	864	2.936765	2.936815	2.936865	2.936916	2.936966	50
50	865	2.937267	2.937317	2.937367	2.937418	2.937468	50
50	866	2.937769	2.937819	2.937869	2.937919	2.937969	50
50	867	2.938269	2.938319	2.938370	2.938420	2.938470	50
50	868	2.938770	2.938820	2.938870	2.938920	2.938970	50
50	869	2.939270	2.939319	2.939369	2.939419	2.939469	50
50	870	2.939769	2.939819	2.939868	2.939918	2.939968	50
50	871	2.940267	2.940317	2.940367	2.940417	2.940467	50
50	872	2.940765	2.940815	2.940865	2.940915	2.940964	50
50	873	2.941262	2.941313	2.941362	2.941412	2.941462	50

F f 2

Num.	0	1	2	3	4	Diff.
874	2.941511	2.941561	2.941611	2.941660	2.941710	50
875	2.942008	2.942058	2.942107	2.942157	2.942206	50
876	2.942504	2.942554	2.942603	2.942653	2.942702	50
877	2.943000	2.943049	2.943099	2.943148	2.943198	49
878	2.943494	2.943544	2.943593	2.943643	2.943692	49
879	2.943989	2.944038	2.944088	2.944137	2.944186	49
880	2.944483	2.944532	2.944581	2.944631	2.944680	49
881	2.944976	2.945025	2.945074	2.945124	2.945173	49
882	2.945469	2.945518	2.945567	2.945616	2.945665	49
883	2.945961	2.946010	2.946059	2.946108	2.946157	49
884	2.946452	2.946501	2.946550	2.946600	2.946649	49
885	2.946943	2.946992	2.947041	2.947090	2.947139	49
886	2.947434	2.947483	2.947532	2.947581	2.947630	49
887	2.947924	2.947973	2.948021	2.948070	2.948119	49
888	2.948413	2.948462	2.948511	2.948560	2.948608	49
889	2.948902	2.948951	2.948999	2.949048	2.949097	49
890	2.949390	2.949439	2.949488	2.949536	2.949585	49
891	2.949878	2.949926	2.949975	2.950024	2.950073	49
892	2.950365	2.950413	2.950462	2.950511	2.950560	49
893	2.950851	2.950900	2.950949	2.950997	2.951046	49
894	2.951237	2.951286	2.951335	2.951383	2.951432	49
895	2.951822	2.951872	2.951920	2.951969	2.952017	49
896	2.952308	2.952356	2.952405	2.952453	2.952502	48
897	2.952792	2.952841	2.952889	2.952938	2.952986	48
898	2.953276	2.953325	2.953373	2.953421	2.953470	48
899	2.953760	2.953808	2.953856	2.953905	2.953953	48
900	2.954242	2.954291	2.954339	2.954387	2.954435	48
901	2.954725	2.954773	2.954821	2.954869	2.954918	48
902	2.955206	2.955255	2.955303	2.955351	2.955399	48
903	2.955688	2.955736	2.955784	2.955832	2.955880	48
904	2.956168	2.956216	2.956264	2.956312	2.956360	48
905	2.956649	2.956697	2.956745	2.956792	2.956840	48
906	2.957128	2.957176	2.957224	2.957272	2.957320	48
907	2.957607	2.957655	2.957703	2.957751	2.957799	48
908	2.958086	2.958134	2.958181	2.958229	2.958277	48
909	2.958564	2.958612	2.958659	2.958707	2.958755	48
910	2.959041	2.959089	2.959137	2.959184	2.959232	48
911	2.959518	2.959566	2.959614	2.959661	2.959709	48
912	2.959995	2.960042	2.960090	2.960138	2.960185	48
913	2.960471	2.960518	2.960566	2.960613	2.960661	48
914	2.960946	2.960994	2.961041	2.961089	2.961136	47
915	2.961421	2.961468	2.961516	2.961563	2.961611	47
916	2.961895	2.961943	2.961990	2.962038	2.962085	47

from 1 to 10000.

(421)

Num.	5	6	7	8	9	Diff.
874	2.941760	2.941809	2.941859	2.941909	2.941958	50
875	2.942256	2.942306	2.942355	2.942405	2.942454	50
876	2.942752	2.942801	2.942851	2.942900	2.942950	50
877	2.943247	2.943297	2.943346	2.943396	2.943445	49
878	2.943742	2.943791	2.943841	2.943890	2.943939	49
879	2.944236	2.944285	2.944335	2.944384	2.944433	49
880	2.944729	2.944779	2.944828	2.944877	2.944927	49
881	2.945222	2.945272	2.945321	2.945370	2.945419	49
882	2.945715	2.945764	2.945813	2.945862	2.945911	49
883	2.946207	2.946256	2.946305	2.946354	2.946403	49
884	2.946698	2.946747	2.946796	2.946845	2.946894	49
885	2.947189	2.947238	2.947287	2.947336	2.947385	49
886	2.947679	2.947728	2.947777	2.947826	2.947875	49
887	2.948168	2.948217	2.948266	2.948315	2.948364	49
888	2.948657	2.948706	2.948755	2.948804	2.948853	49
889	2.949146	2.949195	2.949244	2.949292	2.949341	49
890	2.949633	2.949683	2.949731	2.949780	2.949829	49
891	2.950121	2.950170	2.950219	2.950267	2.950316	49
892	2.950608	2.950657	2.950705	2.950754	2.950803	49
893	2.951095	2.951143	2.951192	2.951240	2.951289	49
894	2.951580	2.951629	2.951677	2.951726	2.951774	49
895	2.952066	2.952114	2.952163	2.952211	2.952259	48
896	2.952550	2.952599	2.952647	2.952696	2.952744	48
897	2.953034	2.953083	2.953131	2.953180	2.953228	48
898	2.953518	2.953566	2.953615	2.953663	2.953711	48
899	2.954001	2.954049	2.954098	2.954146	2.954194	48
900	2.954484	2.954532	2.954580	2.954628	2.954677	48
901	2.954966	2.955014	2.955062	2.955110	2.955158	48
902	2.955447	2.955495	2.955543	2.955591	2.955640	48
903	2.955928	2.955976	2.956024	2.956072	2.956120	48
904	2.956409	2.956457	2.956505	2.956553	2.956601	48
905	2.956888	2.956936	2.956984	2.957032	2.957080	48
906	2.957368	2.957417	2.957464	2.957511	2.957559	48
907	2.957847	2.957894	2.957942	2.957990	2.958038	48
908	2.958325	2.958373	2.958420	2.958468	2.958516	48
909	2.958803	2.958850	2.958898	2.958946	2.958994	48
910	2.959280	2.959328	2.959375	2.959423	2.959471	48
911	2.959757	2.959804	2.959852	2.959900	2.959947	48
912	2.960233	2.960280	2.960328	2.960376	2.960423	48
913	2.960708	2.960756	2.960804	2.960851	2.960899	48
914	2.961184	2.961231	2.961279	2.961326	2.961374	47
915	2.961658	2.961706	2.961753	2.961801	2.961848	47
916	2.962132	2.962180	2.962227	2.962275	2.962322	47

F f 3

Num.	0	1	2	3	4	Diff.
917	2.962369	2.962417	2.962464	2.962511	2.962559	47
918	2.962843	2.962890	2.962937	2.962985	2.963032	47
919	2.963315	2.963363	2.963410	2.963457	2.963504	47
920	2.963788	2.963835	2.963882	2.963929	2.963977	47
921	2.964260	2.964307	2.964354	2.964401	2.964448	47
922	2.964731	2.964778	2.964825	2.964872	2.964919	47
923	2.965252	2.965299	2.965346	2.965393	2.965440	47
924	2.965672	2.965719	2.965766	2.965813	2.965860	47
925	2.966142	2.966189	2.966236	2.966283	2.966329	47
926	2.966611	2.966658	2.966705	2.966752	2.966798	47
927	2.967080	2.967127	2.967173	2.967220	2.967267	47
928	2.967548	2.967595	2.967642	2.967688	2.967735	47
929	2.968016	2.968062	2.968109	2.968156	2.968203	47
930	2.968483	2.968530	2.968576	2.968623	2.968670	47
931	2.968950	2.968996	2.969043	2.969090	2.969136	47
932	2.969416	2.969462	2.969509	2.969556	2.969602	47
933	2.969882	2.969928	2.969975	2.970021	2.970068	47
934	2.970347	2.970393	2.970440	2.970486	2.970533	46
935	2.970812	2.970858	2.970904	2.970951	2.970997	46
936	2.971276	2.971322	2.971369	2.971415	2.971461	46
937	2.971740	2.971786	2.971832	2.971879	2.971925	46
938	2.972203	2.972249	2.972295	2.972342	2.972388	46
939	2.972666	2.972712	2.972758	2.972804	2.972851	46
940	2.973128	2.973174	2.973220	2.973266	2.973313	46
941	2.973590	2.973636	2.973682	2.973728	2.973774	46
942	2.974051	2.974097	2.974143	2.974189	2.974235	46
943	2.974512	2.974558	2.974604	2.974650	2.974696	46
944	2.974972	2.975018	2.975064	2.975110	2.975156	46
945	2.975432	2.975478	2.975524	2.975570	2.975616	46
946	2.975891	2.975937	2.975983	2.976029	2.976075	46
947	2.976350	2.976396	2.976442	2.976487	2.976533	46
948	2.976808	2.976854	2.976900	2.976946	2.976991	46
949	2.977266	2.977312	2.977358	2.977403	2.977449	46
950	2.977724	2.977769	2.977815	2.977861	2.977906	46
951	2.978180	2.978226	2.978272	2.978317	2.978363	46
952	2.978637	2.978683	2.978728	2.978774	2.978819	46
953	2.979093	2.979138	2.979184	2.979230	2.979275	46
954	2.979548	2.979594	2.979639	2.979685	2.979730	46
955	2.980003	2.980049	2.980094	2.980140	2.980185	45
956	2.980458	2.980503	2.980549	2.980594	2.980640	45
957	2.980912	2.980957	2.981003	2.981048	2.981093	45
958	2.981365	2.981411	2.981456	2.981501	2.981547	45
959	2.981819	2.981864	2.981909	2.981954	2.982000	45

from 1 to 10000.

(423)

Num.	5	6	7	8	9	Diff.
917	2.962606	2.962652	2.962701	2.962748	2.962795	47
918	2.963079	2.963126	2.963175	2.963221	2.963268	47
919	2.963552	2.963599	2.963646	2.963693	2.963741	47
920	2.964024	2.964071	2.964118	2.964165	2.964212	47
921	2.964495	2.964542	2.964590	2.964637	2.964684	47
922	2.964966	2.965013	2.965060	2.965108	2.965155	47
923	2.965437	2.965484	2.965531	2.965578	2.965625	47
924	2.965907	2.965954	2.966001	2.966048	2.966095	47
925	2.966376	2.966423	2.966470	2.966517	2.966564	47
926	2.966845	2.966892	2.966939	2.966986	2.967033	47
927	2.967314	2.967361	2.967408	2.967454	2.967501	47
928	2.967782	2.967829	2.967874	2.967922	2.967969	47
929	2.968249	2.968296	2.968343	2.968389	2.968436	47
930	2.968716	2.968763	2.968810	2.968856	2.968903	47
931	2.969183	2.969229	2.969276	2.969322	2.969369	47
932	2.969649	2.969695	2.969742	2.969788	2.969835	47
933	2.970114	2.970161	2.970207	2.970254	2.970300	47
934	2.970579	2.970626	2.970672	2.970719	2.970765	46
935	2.971044	2.971090	2.971137	2.971180	2.971229	46
936	2.971508	2.971554	2.971600	2.971645	2.971693	46
937	2.971971	2.972018	2.972064	2.972110	2.972156	46
938	2.972434	2.972480	2.972527	2.972573	2.972619	46
939	2.972897	2.972943	2.972989	2.973035	2.973082	46
940	2.973359	2.973405	2.973451	2.973495	2.973543	46
941	2.973820	2.973866	2.973913	2.973959	2.974005	46
942	2.974281	2.974327	2.974373	2.974420	2.974466	46
943	2.974742	2.974788	2.974834	2.974880	2.974926	46
944	2.975202	2.975248	2.975294	2.975340	2.975386	46
945	2.975661	2.975707	2.975753	2.975799	2.975845	46
946	2.976121	2.976166	2.976212	2.976258	2.976304	46
947	2.976579	2.976625	2.976671	2.976717	2.976762	46
948	2.977037	2.977083	2.977129	2.977175	2.977220	46
949	2.977495	2.977541	2.977586	2.977632	2.977678	46
950	2.977952	2.977998	2.978043	2.978089	2.978135	46
951	2.978409	2.978454	2.978500	2.978546	2.978591	46
952	2.978865	2.978911	2.978956	2.979002	2.979047	46
953	2.979321	2.979366	2.979412	2.979457	2.979503	46
954	2.979776	2.979821	2.979867	2.979912	2.979958	46
955	2.980231	2.980276	2.980322	2.980367	2.980412	45
956	2.980685	2.980730	2.980776	2.980821	2.980867	45
957	2.981139	2.981184	2.981229	2.981275	2.981320	45
958	2.981592	2.981637	2.981683	2.981728	2.981773	45
959	2.982045	2.982090	2.982135	2.982181	2.982226	45

Ff 4

Num.	0	1	2	3	4	Diff.
960	2.982271	2.982316	2.982362	2.982407	2.982452	45
961	2.982723	2.982769	2.982814	2.982859	2.982904	45
962	2.983175	2.983220	2.983265	2.983310	2.983356	45
963	2.983626	2.983671	2.983716	2.983762	2.983807	45
964	2.984077	2.984122	2.984167	2.984212	2.984257	45
965	2.984527	2.984572	2.984617	2.984662	2.984707	45
966	2.984977	2.985022	2.985067	2.985112	2.985157	45
967	2.985426	2.985471	2.985516	2.985561	2.985606	45
968	2.985875	2.985920	2.985965	2.986010	2.986055	45
969	2.986324	2.986369	2.986413	2.986458	2.986503	45
970	2.986772	2.986816	2.986861	2.986906	2.986951	45
971	2.987219	2.987264	2.987309	2.987353	2.987398	45
972	2.987666	2.987711	2.987756	2.987800	2.987845	45
973	2.988113	2.988157	2.988202	2.988247	2.988291	45
974	2.988559	2.988603	2.988648	2.988693	2.988737	45
975	2.989005	2.989049	2.989094	2.989138	2.989183	45
976	2.989450	2.989494	2.989539	2.989583	2.989628	44
977	2.989895	2.989939	2.989983	2.990028	2.990072	44
978	2.990339	2.990383	2.990428	2.990472	2.990516	44
979	2.990783	2.990827	2.990871	2.990916	2.990960	44
980	2.991226	2.991270	2.991315	2.991359	2.991403	44
981	2.991669	2.991713	2.991757	2.991802	2.991846	44
982	2.992111	2.992156	2.992200	2.992244	2.992289	44
983	2.992553	2.992598	2.992642	2.992686	2.992730	44
984	2.992995	2.993039	2.993083	2.993127	2.993172	44
985	2.993436	2.993480	2.993524	2.993568	2.993613	44
986	2.993877	2.993921	2.993965	2.994009	2.994053	44
987	2.994317	2.994361	2.994405	2.994449	2.994493	44
988	2.994757	2.994801	2.994845	2.994889	2.994933	44
989	2.995196	2.995240	2.995284	2.995328	2.995372	44
990	2.995535	2.995579	2.995623	2.995667	2.995711	44
991	2.995974	2.996017	2.996061	2.996105	2.996149	44
992	2.996512	2.996555	2.996599	2.996643	2.996687	44
993	2.996949	2.996993	2.997037	2.997080	2.997124	44
994	2.997386	2.997430	2.997474	2.997517	2.997561	44
995	2.997823	2.997867	2.997910	2.997954	2.997998	44
996	2.998259	2.998303	2.998346	2.998390	2.998434	44
997	2.998695	2.998739	2.998782	2.998826	2.998869	44
998	2.999130	2.999174	2.999218	2.999261	2.999305	44
999	2.999565	2.999609	2.999652	2.999696	2.999739	43

from 1 to 10000.

(425)

Num.	5	6	7	8	9	Diff
960	2.982497	2.982543	2.982588	2.982633	2.982678	45
961	2.982949	2.982994	2.983040	2.983085	2.983130	45
962	2.983401	2.983446	2.983491	2.983536	2.983581	45
963	2.983852	2.983897	2.983942	2.983987	2.984032	45
964	2.984302	2.984347	2.984392	2.984437	2.984482	45
965	2.984752	2.984797	2.984842	2.984887	2.984932	45
966	2.985202	2.985246	2.985292	2.985337	2.985382	45
967	2.985651	2.985695	2.985741	2.985786	2.985830	45
968	2.986100	2.986144	2.986189	2.986234	2.986279	45
969	2.986548	2.986593	2.986637	2.986682	2.986727	45
970	2.986995	2.987040	2.987085	2.987130	2.987174	45
971	2.987443	2.987487	2.987532	2.987577	2.987622	45
972	2.987890	2.987934	2.987979	2.988024	2.988068	45
973	2.988336	2.988381	2.988425	2.988470	2.988514	45
974	2.988782	2.988826	2.988871	2.988915	2.988960	45
975	2.989227	2.989272	2.989316	2.989361	2.989405	45
976	2.989672	2.989717	2.989761	2.989806	2.989850	44
977	2.990117	2.990161	2.990206	2.990250	2.990294	44
978	2.990564	2.990605	2.990650	2.990694	2.990738	44
979	2.991004	2.991049	2.991093	2.991137	2.991182	44
980	2.991448	2.991492	2.991536	2.991580	2.991625	44
981	2.991890	2.991934	2.991979	2.992023	2.992067	44
982	2.992333	2.992377	2.992421	2.992465	2.992509	44
983	2.992774	2.992818	2.992863	2.992907	2.992951	44
984	2.993216	2.993260	2.993304	2.993348	2.993392	44
985	2.993657	2.993701	2.993745	2.993789	2.993833	44
986	2.994097	2.994141	2.994185	2.994229	2.994273	44
987	2.994537	2.994581	2.994625	2.994669	2.994713	44
988	2.994977	2.995021	2.995064	2.995108	2.995152	44
989	2.995416	2.995460	2.995504	2.995547	2.995591	44
990	2.995854	2.995898	2.995942	2.995985	2.996030	44
991	2.996293	2.996336	2.996380	2.996424	2.996468	44
992	2.996730	2.996774	2.996818	2.996862	2.996905	44
993	2.997168	2.997212	2.997255	2.997299	2.997343	44
994	2.997605	2.997648	2.997691	2.997736	2.997779	44
995	2.998041	2.998085	2.998128	2.998172	2.998216	44
996	2.998477	2.998521	2.998564	2.998608	2.998652	44
997	2.998913	2.998956	2.999000	2.999043	2.999087	44
998	2.999348	2.999392	2.999435	2.999478	2.999522	44
999	2.999783	2.999826	2.999870	2.999913	2.999957	43

0 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
0	0.060000	10.000000	0.000000	Infinite.	10.000000	Infinite.	60
1	6.463726	9.999999	6.463726	13.536274	10.000000	13.536274	59
2	6.764756	9.999999	6.764756	13.235244	10.000000	13.235244	58
3	6.940847	9.999999	6.940847	13.059152	10.000000	13.059152	57
4	7.065785	9.999999	7.065786	12.934214	10.000000	12.934214	56
5	7.162696	9.999999	7.162696	12.837304	10.000000	12.837304	55
6	7.241877	9.999999	7.241878	12.758122	10.000001	12.758123	54
7	7.308824	9.999999	7.308825	12.691175	10.000001	12.691176	53
8	7.366816	9.999995	7.366817	12.633183	10.000001	12.633184	52
9	7.417968	9.999998	7.417970	12.582030	10.000001	12.582032	51
10	7.463725	9.999998	7.463727	12.536273	10.000002	12.536274	50
11	7.505118	9.999998	7.505120	12.494880	10.000002	12.494882	49
12	7.542906	9.999997	7.542909	12.457091	10.000003	12.457093	48
13	7.577668	9.999997	7.577671	12.422328	10.000003	12.422322	47
14	7.609853	9.999996	7.609857	12.390143	10.000004	12.390147	46
15	7.639816	9.999996	7.639820	12.360180	10.000004	12.360184	45
16	7.667844	9.999995	7.667849	12.332151	10.000005	12.332155	44
17	7.694173	9.999995	7.694179	12.305821	10.000005	12.305827	43
18	7.718997	9.999994	7.719003	12.280997	10.000006	12.281003	42
19	7.742477	9.999993	7.742484	12.257516	10.000007	12.257522	41
20	7.764714	9.999993	7.764761	12.235219	10.000007	12.235246	40
21	7.785943	9.999992	7.785951	12.214049	10.000008	12.214057	39
22	7.806146	9.999991	7.806155	12.193845	10.000009	12.193854	38
23	7.825451	9.999990	7.825460	12.174540	10.000010	12.174549	37
24	7.843934	9.999989	7.843944	12.156056	10.000011	12.156066	36
25	7.861662	9.999988	7.861674	12.138326	10.000011	12.138338	35
26	7.878695	9.999988	7.878708	12.121292	10.000012	12.121305	34
27	7.895085	9.999987	7.895099	12.104901	10.000013	12.104915	33
28	7.910879	9.999986	7.910894	12.089106	10.000014	12.089121	32
29	7.926119	9.999984	7.926134	12.073866	10.000015	12.073881	31
30	7.940842	9.999983	7.940858	12.059142	10.000016	12.059158	30
		Sine.		Tang.		Secant.	Min.

89 Degrees.

Tangents and Secants.

427

o Degrees.

Min.	Sine.		Tang		Secant.	
60	7.940842	9.999983	7.940858	12.059142	10.000016	12.059158 30
59	7.955082	9.999982	7.955100	12.044900	10.000018	12.044918 29
58	7.968870	9.999981	7.968889	12.031111	10.000019	12.031130 28
57	7.982233	9.999980	7.982253	12.017747	10.000020	12.017767 27
56	7.995198	9.999979	7.995219	12.004781	10.000021	12.004802 26
55	8.007787	9.999977	8.007809	11.992191	10.000022	11.992213 25
54	8.020021	9.999976	8.020044	11.979955	10.000024	11.979979 24
53	8.031919	9.999975	8.031945	11.968055	10.000025	11.968080 23
52	8.043501	9.999973	8.043527	11.956473	10.000026	11.956499 22
51	8.054781	9.999972	8.054809	11.945191	10.000028	11.945219 21
50	8.065776	9.999971	8.065806	11.934194	10.000029	11.934224 20
49	8.076500	9.999969	8.076531	11.923469	10.000031	11.923500 19
48	8.086965	9.999968	8.086997	11.913003	10.000032	11.913035 18
47	8.097183	9.999966	8.097217	11.902783	10.000034	11.902817 17
46	8.107167	9.999964	8.107202	11.892707	10.000036	11.892833 16
45	8.116926	9.999963	8.116963	11.883037	10.000037	11.883074 15
44	8.126471	9.999961	8.126510	11.873499	10.000039	11.873529 14
43	8.135810	9.999959	8.135851	11.864149	10.000041	11.864190 13
42	8.144953	9.999958	8.144996	11.855004	10.000042	11.855047 12
41	8.153907	9.999956	8.153952	11.846048	10.000044	11.846092 11
40	8.162681	9.999954	8.162727	11.837273	10.000046	11.837319 10
39	8.171280	9.999952	8.171328	11.828672	10.000048	11.828726 9
38	8.179713	9.999950	8.179763	11.820237	10.000050	11.820287 8
37	8.187985	9.999948	8.188036	11.811964	10.000052	11.812015 7
36	8.196102	9.999946	8.196156	11.803844	10.000054	11.803898 6
35	8.204070	9.999944	8.204126	11.795874	10.000056	11.795930 5
34	8.211895	9.999942	8.211953	11.788047	10.000058	11.788105 4
33	8.219581	9.999940	8.219641	11.780359	10.000060	11.780419 3
32	8.227133	9.999938	8.227195	11.772805	10.000062	11.772866 2
31	8.234557	9.999936	8.234621	11.765379	10.000064	11.765443 1
30	8.241855	9.999934	8.241921	11.758078	10.000066	11.758145 0
	Sine.		Tang.		Secant.	Min.

89 Degrees.

1 Degree.

Min.	Sine.		Tang.		Secant.	
0	8.241855	9.999934	8.241921	11.758078	10.000066	11.758145
1	8.249033	9.999932	8.249101	11.758098	10.000068	11.758067
2	8.256094	9.999929	8.256165	11.743835	10.000071	11.743906
3	8.263042	9.999927	8.263115	11.736885	10.000073	11.736958
4	8.269881	9.999925	8.269956	11.730044	10.000075	11.730119
5	8.276614	9.999922	8.276691	11.723309	10.000078	11.723386
6	8.283243	9.999920	8.283323	11.716677	10.000080	11.716757
7	8.289773	9.999917	8.289856	11.710144	10.000082	11.710227
8	8.296207	9.999915	8.296292	11.703708	10.000085	11.703793
9	8.302546	9.999912	8.302633	11.697366	10.000087	11.697454
10	8.308794	9.999910	8.308884	11.691116	10.000090	11.691206
11	8.314954	9.999907	8.315046	11.684954	10.000093	11.685046
12	8.321027	9.999905	8.321122	11.678878	10.000095	11.678973
13	8.327016	9.999902	8.327114	11.672886	10.000098	11.672984
14	8.332924	9.999899	8.333025	11.666975	10.000101	11.667076
15	8.338753	9.999897	8.338856	11.661144	10.000103	11.661247
16	8.344504	9.999894	8.344610	11.655389	10.000106	11.655496
17	8.350180	9.999891	8.350289	11.649710	10.000109	11.649819
18	8.355783	9.999888	8.355895	11.644105	10.000112	11.644216
19	8.361315	9.999885	8.361430	11.638570	10.000115	11.638685
20	8.366777	9.999882	8.366894	11.633105	10.000118	11.633223
21	8.372171	9.999879	8.372291	11.627708	10.000121	11.627829
22	8.377499	9.999876	8.377622	11.622378	10.000124	11.622501
23	8.382762	9.999873	8.382889	11.617111	10.000127	11.617238
24	8.387962	9.999870	8.388092	11.611908	10.000130	11.612038
25	8.393101	9.999867	8.393234	11.606766	10.000133	11.606899
26	8.398176	9.999864	8.398315	11.601685	10.000136	11.601821
27	8.403199	9.999861	8.403338	11.596662	10.000139	11.596801
28	8.408161	9.999858	8.408304	11.591696	10.000142	11.591839
29	8.413068	9.999854	8.413213	11.586787	10.000146	11.586932
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081
		Sine.		Tang.		Secant.

88 Degrees.

Tangents and Secants.

429

1 Degree.

Min.	Sine.		Tang.		Secant		Min.
60	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
59	8.422717	9.999848	8.422869	11.577131	10.000152	11.577283	29
58	8.427462	9.999844	8.427618	11.572382	10.000155	11.572538	28
57	8.432156	9.999841	8.432315	11.567685	10.000159	11.567844	27
56	8.436800	9.999838	8.436962	11.563038	10.000162	11.563200	26
55	8.441394	9.999834	8.441560	11.558440	10.000166	11.558606	25
54	8.445941	9.999831	8.446110	11.553890	10.000169	11.554059	24
53	8.450440	9.999827	8.450613	11.549387	10.000173	11.549560	23
52	8.454893	9.999823	8.455070	11.544930	10.000176	11.545107	22
51	8.459301	9.999820	8.459481	11.540519	10.000180	11.540699	21
50	8.463665	9.999816	8.463849	11.536151	10.000184	11.536335	20
49	8.467985	9.999812	8.468172	11.531827	10.000187	11.532015	19
48	8.472263	9.999809	8.472454	11.527546	10.000191	11.527737	18
47	8.476498	9.999805	8.476693	11.523307	10.000195	11.523502	17
46	8.480693	9.999801	8.480892	11.519108	10.000199	11.519307	16
45	8.484848	9.999797	8.485050	11.514949	10.000203	11.515152	15
44	8.488963	9.999793	8.489170	11.510830	10.000206	11.511037	14
43	8.493040	9.999790	8.493250	11.506750	10.000210	11.506960	13
42	8.497078	9.999786	8.497293	11.502707	10.000214	11.502922	12
41	8.501080	9.999782	8.501298	11.498702	10.000218	11.498920	11
40	8.505045	9.999778	8.505267	11.494733	10.000222	11.494955	10
39	8.508974	9.999774	8.509200	11.490800	10.000226	11.491026	9
38	8.512867	9.999769	8.513098	11.486902	10.000230	11.487133	8
37	8.516726	9.999765	8.516961	11.483039	10.000235	11.483274	7
36	8.520551	9.999761	8.520790	11.479210	10.000239	11.479449	6
35	8.524343	9.999757	8.524586	11.475414	10.000243	11.475657	5
34	8.528102	9.999753	8.528349	11.471651	10.000247	11.471898	4
33	8.531828	9.999748	8.532080	11.467920	10.000252	11.468172	3
32	8.535523	9.999744	8.535779	11.464221	10.000256	11.464477	2
31	8.539186	9.999740	8.539447	11.460553	10.000260	11.460814	1
30	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	0
	Sine.		Tang.		Secant.		Min.

88 Degrees.

Min.	Sine.		Tang.		Secant.	
0	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181
1	8.546422	9.999731	8.546691	11.453309	10.000269	11.453578
2	8.549995	9.999726	8.550268	11.444732	10.000273	11.450005
3	8.553539	9.999722	8.553817	11.446183	10.000278	11.446461
4	8.557054	9.999717	8.557336	11.442664	10.000283	11.442946
5	8.560540	9.999713	8.560828	11.439172	10.000287	11.439460
6	8.563999	9.999708	8.564291	11.435709	10.000292	11.436001
7	8.567431	9.999704	8.567727	11.432272	10.000296	11.432569
8	8.570836	9.999699	8.571137	11.428863	10.000301	11.429164
9	8.574214	9.999694	8.574520	11.425480	10.000306	11.425786
10	8.577566	9.999689	8.577877	11.422123	10.000311	11.422434
11	8.580892	9.999685	8.581208	11.418792	10.000315	11.419108
12	8.584193	9.999680	8.584514	11.415486	10.000320	11.415807
13	8.587469	9.999675	8.587794	11.412206	10.000325	11.412531
14	8.590721	9.999670	8.591051	11.408949	10.000330	11.409279
15	8.593948	9.999665	8.594283	11.405717	10.000335	11.406052
16	8.597152	9.999660	8.597492	11.402508	10.000340	11.402848
17	8.600332	9.999655	8.600677	11.399323	10.000345	11.399668
18	8.603489	9.999650	8.603839	11.396161	10.000350	11.396511
19	8.606623	9.999645	8.606978	11.393022	10.000355	11.393377
20	8.609734	9.999640	8.610094	11.389905	10.000360	11.390266
21	8.612823	9.999635	8.613189	11.386811	10.000365	11.387176
22	8.615891	9.999629	8.616262	11.383738	10.000371	11.384109
23	8.618937	9.999624	8.619313	11.380687	10.000376	11.381063
24	8.621962	9.999618	8.622343	11.377657	10.000381	11.378038
25	8.624965	9.999614	8.625352	11.374648	10.000386	11.375035
26	8.627948	9.999608	8.628340	11.371660	10.000392	11.372052
27	8.630911	9.999603	8.631308	11.368692	10.000397	11.369089
28	8.633854	9.999597	8.634256	11.365744	10.000403	11.366140
29	8.636776	9.999592	8.637184	11.362815	10.000408	11.363224
30	8.639680	9.999586	8.640093	11.359906	10.000413	11.360320
	Sine.		Tang.		Secant.	

431

Min.	Sine.	Tang.	Secant.
30	8.039680	9.999586	8.640093
31	8.642563	9.999581	8.642982
32	8.645428	9.999575	8.645853
33	8.648274	9.999570	8.648704
34	8.651162	9.999564	8.651537
35	8.653911	9.999558	8.654352
36	8.656702	9.999553	8.657149
37	8.659475	9.999547	8.659928
38	8.662230	9.999541	8.662689
39	8.664968	9.999535	8.665433
40	8.667689	9.999529	8.668160
41	8.670393	9.999524	8.670870
42	8.673080	9.999518	8.673563
43	8.675751	9.999512	8.676239
44	8.678405	9.999506	8.678900
45	8.681043	9.999500	8.681544
46	8.683665	9.999493	8.684172
47	8.686272	9.999487	8.686784
48	8.688863	9.999481	8.689381
49	8.691438	9.999475	8.691963
50	8.693998	9.999469	8.694529
51	8.696543	9.999462	8.697081
52	8.699073	9.999456	8.699617
53	8.701589	9.999450	8.702139
54	8.704090	9.999443	8.704646
55	8.706577	9.999437	8.707139
56	8.709049	9.999431	8.709618
57	8.711507	9.999424	8.712083
58	8.713952	9.999418	8.714534
59	8.716383	9.999411	8.716972
60	8.718800	9.999404	8.719396
	Sine.	Tang.	Secant.

87 Degrees.

2 Degrees.

Min.	Sine.		Tang.		Secant.	
1	8.718800	9.999404	8.719396	11.280604	10.000596	11.281200
2	8.721204	9.999398	8.721806	11.278194	10.000602	11.278796
3	8.723595	9.999391	8.724203	11.275796	10.000609	11.276405
4	8.725972	9.999384	8.726588	11.273412	10.000616	11.274028
5	8.728337	9.999378	8.728959	11.271041	10.000622	11.271663
6	8.730688	9.999371	8.731317	11.268683	10.000629	11.269312
7	8.733027	9.999364	8.733663	11.266337	10.000636	11.266973
8	8.735353	9.999357	8.735996	11.264004	10.000643	11.264646
9	8.737667	9.999350	8.738317	11.261683	10.000650	11.262332
10	8.739969	9.999343	8.740626	11.259374	10.000657	11.260031
11	8.742259	9.999336	8.742922	11.257078	10.000664	11.257741
12	8.744536	9.999329	8.745207	11.254793	10.000671	11.255464
13	8.746801	9.999322	8.747479	11.252521	10.000678	11.253198
14	8.749055	9.999315	8.749740	11.250260	10.000685	11.250945
15	8.751297	9.999308	8.751989	11.248011	10.000692	11.248703
16	8.753528	9.999301	8.754227	11.245773	10.000699	11.246472
17	8.755747	9.999294	8.756453	11.243547	10.000706	11.244253
18	8.757955	9.999286	8.758668	11.241332	10.000713	11.242045
19	8.760151	9.999279	8.760872	11.239128	10.000721	11.239849
20	8.762337	9.999272	8.762065	11.236935	10.000728	11.237663
21	8.764511	9.999265	8.765246	11.234753	10.000735	11.235489
22	8.766675	9.999257	8.767417	11.232582	10.000743	11.233325
23	8.768837	9.999250	8.769578	11.230422	10.000750	11.231172
24	8.770970	9.999242	8.771727	11.228273	10.000758	11.229030
25	8.773101	9.999235	8.773866	11.226133	10.000765	11.226899
26	8.775223	9.999227	8.775995	11.224005	10.000773	11.224777
27	8.777333	9.999220	8.778114	11.221886	10.000780	11.222667
28	8.779434	9.999212	8.780222	11.219778	10.000788	11.220566
29	8.781524	9.999205	8.782320	11.217680	10.000795	11.218475
30	8.783605	9.999197	8.784408	11.215592	10.000803	11.216395
31	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325
	Sine.		Tang.		Secant.	

86 Degrees.

Tangents and Secants.

433

3 Degrees.

Min.	Sine.		Tang.		Secant.	
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325
31	8.787735	9.999181	8.788554	11.211446	10.000818	11.212264
32	8.789787	9.999174	8.790613	11.209387	10.000826	11.210213
33	8.791828	9.999166	8.792662	11.207338	10.000834	11.208172
34	8.793859	9.999158	8.794701	11.205299	10.000842	11.206141
35	8.795881	9.999150	8.796732	11.203269	10.000850	11.204119
36	8.797894	9.999142	8.798750	11.201248	10.000858	11.202106
37	8.799897	9.999134	8.800763	11.199237	10.000866	11.200102
38	8.801891	9.999126	8.802765	11.197235	10.000874	11.198108
39	8.803876	9.999118	8.804758	11.195242	10.000882	11.196124
40	8.805852	9.999110	8.806742	11.193258	10.000890	11.194148
41	8.807819	9.999102	8.808717	11.191283	10.000898	11.192181
42	8.809777	9.999094	8.810683	11.189317	10.000906	11.190222
43	8.811726	9.999086	8.812641	11.187359	10.000914	11.188274
44	8.813666	9.999077	8.814589	11.185411	10.000923	11.186333
45	8.815598	9.999069	8.816529	11.183471	10.000931	11.184401
46	8.817522	9.999061	8.818461	11.181539	10.000939	11.182478
47	8.819436	9.999052	8.820384	11.179610	10.000948	11.180564
48	8.821342	9.999044	8.822298	11.177702	10.000956	11.178657
49	8.823240	9.999036	8.824205	11.175795	10.000964	11.176760
50	8.825130	9.999027	8.826103	11.173897	10.000973	11.174870
51	8.827011	9.999019	8.827992	11.172008	10.000981	11.172989
52	8.828884	9.999010	8.829874	11.170126	10.000990	11.171116
53	8.830749	9.999002	8.831748	11.168252	10.000998	11.169250
54	8.832607	9.998993	8.833613	11.166387	10.001007	11.167393
55	8.834456	9.998984	8.835471	11.164526	10.001015	11.165544
56	8.836297	9.998976	8.837321	11.162679	10.001024	11.163703
57	8.838130	9.998967	8.839163	11.160837	10.001033	11.161870
58	8.839956	9.998958	8.840999	11.159002	10.001042	11.160044
59	8.841774	9.998950	8.842824	11.157175	10.001050	11.158226
60	8.843584	9.998941	8.844644	11.155356	10.001059	11.156415
	Sine.		Tang.		Secant.	Min.

86 Degrees.

G 8

4 Degrees.

Min.	Sine.		Tang.		Secant.	
0	8.843584	9.998941	8.844044	11.155359	10.001056	11.156415
1	8.845387	9.998932	8.846455	11.153545	10.001068	11.154613
2	8.847183	9.998923	8.848260	11.151740	10.001077	11.152817
3	8.848971	9.998914	8.850057	11.149943	10.001086	11.151029
4	8.850751	9.998905	8.851846	11.148154	10.001095	11.149249
5	8.852524	9.998896	8.853628	11.146372	10.001104	11.147475
6	8.854290	9.998887	8.855403	11.144597	10.001113	11.145709
7	8.856049	9.998878	8.857171	11.142829	10.001122	11.143951
8	8.857801	9.998869	8.858932	11.141068	10.001131	11.142199
9	8.859946	9.998860	8.860686	11.139314	10.001140	11.140554
10	8.861283	9.998851	8.862433	11.137567	10.001149	11.138717
11	8.863014	9.998841	8.864172	11.135827	10.001159	11.136986
12	8.864738	9.998832	8.865905	11.134094	10.001168	11.135262
13	8.866454	9.998823	8.867632	11.132368	10.001177	11.133554
14	8.868165	9.998813	8.869351	11.130649	10.001186	11.131835
15	8.869868	9.998804	8.871064	11.128936	10.001196	11.130132
16	8.871565	9.998795	8.872770	11.127230	10.001205	11.128435
17	8.873255	9.998785	8.874469	11.125531	10.001215	11.126745
18	8.874938	9.998776	8.876162	11.123838	10.001224	11.125062
19	8.876615	9.998766	8.877849	11.122151	10.001234	11.123385
20	8.878285	9.998757	8.879529	11.120471	10.001243	11.121715
21	8.879949	9.998747	8.881202	11.118798	10.001253	11.120051
22	8.881607	9.998737	8.882869	11.117131	10.001262	11.118343
23	8.883258	9.998728	8.884530	11.115470	10.001272	11.116674
24	8.884903	9.998718	8.886185	11.113815	10.001282	11.115097
25	8.886542	9.998708	8.887833	11.112167	10.001292	11.113458
26	8.888174	9.998699	8.889476	11.110524	10.001301	11.111826
27	8.889801	9.998689	8.891112	11.108888	10.001311	11.110199
28	8.891421	9.998679	8.892742	11.107258	10.001321	11.108579
29	8.893035	9.998669	8.894366	11.105634	10.001331	11.106965
30	8.894643	9.998659	8.895984	11.104016	10.001341	11.105357
	Sine.		Tang.		Secant.	

85 Degrees.

Tangents and Secants.

435

4 Degrees.

Min.	Sine.	Tang.	Secant.	
30	8.894643	9.998659	8.895984	11.104016
31	8.896245	9.998649	8.897596	11.102404
32	8.897842	9.998639	8.899203	11.100797
33	8.899432	9.998629	8.900803	11.099197
34	8.901017	9.998619	8.902398	11.097602
35	8.902595	9.998609	8.903987	11.096013
36	8.904268	9.998599	8.905570	11.094430
37	8.905936	9.998588	8.907147	11.092853
38	8.907597	9.998578	8.908719	11.091281
39	8.908853	9.998568	8.910285	11.089715
40	8.910404	9.998558	8.911846	11.088154
41	8.911949	9.998547	8.913401	11.086599
42	8.913488	9.998537	8.914951	11.085049
43	8.915022	9.998527	8.916495	11.083505
44	8.916550	9.998516	8.918034	11.081966
45	8.918073	9.998506	8.919567	11.080432
46	8.919591	9.998495	8.921096	11.078904
47	8.921103	9.998485	8.922619	11.077381
48	8.922610	9.998474	8.924136	11.075864
49	8.924112	9.998464	8.925649	11.074351
50	8.925609	9.998453	8.927156	11.072844
51	8.927100	9.998442	8.928658	11.071342
52	8.928587	9.998431	8.930155	11.069845
53	8.930068	9.998421	8.931647	11.068353
54	8.931544	9.998410	8.933134	11.066866
55	8.933015	9.998399	8.934616	11.065384
56	8.934481	9.998388	8.936093	11.063907
57	8.935942	9.998377	8.937565	11.062435
58	8.937398	9.998366	8.939032	11.060968
59	8.938850	9.998355	8.940494	11.059506
60	8.940296	9.998344	8.941952	11.058048
	Sine.	Tang.	Secant.	Min.

85 Degrees.

G g 2

5 Degrees.

Min.	Sine.		Tang.		Secant.	
0	8.940290	9.998344	8.941952	11.058048	10.001656	11.059704
1	8.941738	9.998333	8.943404	11.056596	10.001667	11.058262
2	8.943174	9.998322	8.944852	11.055148	10.001678	11.056826
3	8.944606	9.998311	8.946295	11.053705	10.001689	11.055394
4	8.946032	9.998300	8.947734	11.052266	10.001700	11.053966
5	8.947450	9.998288	8.949168	11.050832	10.001711	11.052544
6	8.948874	9.998277	8.950597	11.049403	10.001723	11.051125
7	8.950287	9.998266	8.952021	11.047979	10.001734	11.049713
8	8.951696	9.998255	8.953441	11.046559	10.001745	11.048304
9	8.953100	9.998243	8.954856	11.045144	10.001757	11.046900
10	8.954499	9.998232	8.956267	11.043733	10.001768	11.045501
11	8.955896	9.998220	8.957673	11.042326	10.001780	11.044106
12	8.957284	9.998209	8.959075	11.040925	10.001791	11.042716
13	8.958670	9.998197	8.960473	11.039527	10.001802	11.041330
14	8.960052	9.998186	8.961866	11.038134	10.001814	11.039948
15	8.961429	9.998174	8.963254	11.036745	10.001826	11.038571
16	8.962801	9.998163	8.964639	11.035361	10.001837	11.037199
17	8.964170	9.998151	8.966029	11.033981	10.001849	11.035830
18	8.965534	9.998139	8.967394	11.032606	10.001861	11.034466
19	8.966893	9.998127	8.968766	11.031234	10.001872	11.033107
20	8.968249	9.998116	8.970133	11.029867	10.001883	11.031751
21	8.969600	9.998104	8.971496	11.028504	10.001896	11.030400
22	8.970947	9.998092	8.972855	11.027145	10.001908	11.029053
23	8.972289	9.998080	8.974209	11.025791	10.001920	11.027710
24	8.973628	9.998068	8.975560	11.024440	10.001932	11.026372
25	8.974962	9.998056	8.976906	11.023094	10.001944	11.025038
26	8.976293	9.998044	8.978248	11.021752	10.001956	11.023707
27	8.977619	9.998032	8.979586	11.020413	10.001968	11.022381
28	8.978941	9.998020	8.980921	11.019079	10.001980	11.021059
29	8.980259	9.998008	8.982251	11.017749	10.001992	11.019741
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427
		Sine.		Tang		Secant.

84 Degrees.

Tangents and Secants.

437

5 Degrees.

Min.	Sine.		Tang.		Secant.		
10	8.981573	9.997996	8.983577	11.015423	10.002004	11.018427	30
11	8.982883	9.997984	8.984899	11.015101	10.002016	11.017117	29
12	8.984189	9.997972	8.986217	11.013783	10.002028	11.015811	28
13	8.985491	9.997959	8.987532	11.012468	10.002041	11.014509	27
14	8.986789	9.997947	8.988842	11.011158	10.002053	11.013211	26
15	8.988083	9.997935	8.990149	11.009851	10.002065	11.011917	25
16	8.989374	9.997922	8.991451	11.008549	10.002078	11.010626	24
17	8.990660	9.997910	8.992750	11.007250	10.002090	11.009340	23
18	8.991943	9.997897	8.994045	11.005955	10.002102	11.008057	22
19	8.993222	9.997885	8.995337	11.004663	10.002115	11.006778	21
20	8.994467	9.997872	8.996624	11.003376	10.002127	11.005503	20
21	8.995768	9.997860	8.997908	11.002092	10.002141	11.004232	19
22	8.997036	9.997847	8.999188	11.000812	10.002153	11.002964	18
23	8.998299	9.997835	9.000465	10.999535	10.002165	11.001701	17
24	8.999599	9.997822	9.001737	10.998262	10.002178	11.000440	16
25	9.000816	9.997809	9.003007	10.996993	10.002191	10.999184	15
26	9.002069	9.997797	9.004272	10.995728	10.002203	10.997931	14
27	9.003318	9.997784	9.005534	10.994466	10.002216	10.996682	13
28	9.004553	9.997771	9.006792	10.993208	10.002229	10.995437	12
29	9.005805	9.997758	9.008047	10.991953	10.002242	10.994195	11
30	9.007044	9.997745	9.009298	10.990702	10.002255	10.992956	10
31	9.008278	9.997732	9.010546	10.989454	10.002268	10.991722	9
32	9.009510	9.997719	9.011790	10.988210	10.002281	10.990490	8
33	9.010737	9.997706	9.013031	10.986969	10.002294	10.989263	7
34	9.011962	9.997693	9.014268	10.985732	10.002307	10.988038	6
35	9.013182	9.997680	9.015502	10.984498	10.002320	10.986818	5
36	9.014400	9.997667	9.016732	10.983267	10.002333	10.985600	4
37	9.015613	9.997654	9.017959	10.982041	10.002346	10.984386	3
38	9.016824	9.997641	9.019183	10.980817	10.002359	10.983176	2
39	9.018031	9.997628	9.020417	10.979597	10.002372	10.981969	1
40	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	0
	Sine.		Tang.		Secant.		Min.

84 Degrees.

G g 3

6 Degrees.

Min.	Sine.		Tang		Secant.	
1	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765
2	9.020435	9.997601	9.022834	10.977166	10.002399	10.979565
3	9.021632	9.997588	9.024044	10.975956	10.002412	10.978368
4	9.022825	9.997574	9.025251	10.974749	10.002426	10.977175
5	9.024016	9.997561	9.026455	10.973545	10.002439	10.975984
6	9.025203	9.997547	9.027655	10.972345	10.002452	10.974797
7	9.026386	9.997534	9.028852	10.971148	10.002466	10.973613
8	9.027567	9.997520	9.030046	10.969954	10.002479	10.972433
9	9.028744	9.997507	9.031237	10.968763	10.002493	10.971256
10	9.029918	9.997493	9.032425	10.967575	10.002507	10.970082
11	9.031089	9.997480	9.033609	10.966391	10.002520	10.968911
12	9.032257	9.997466	9.034791	10.965209	10.002534	10.967743
13	9.033421	9.997452	9.035969	10.964031	10.002548	10.966579
14	9.034582	9.997439	9.037144	10.962856	10.002561	10.965417
15	9.035741	9.997425	9.038316	10.961684	10.002575	10.964259
16	9.036896	9.997411	9.039485	10.960515	10.002589	10.963104
17	9.038048	9.997397	9.040651	10.959349	10.002603	10.961952
18	9.039197	9.997383	9.041813	10.958187	10.002617	10.960803
19	9.040342	9.997369	9.042973	10.957027	10.002631	10.959658
20	9.041485	9.997355	9.044130	10.955870	10.002645	10.958515
21	9.042625	9.997341	9.045284	10.954716	10.002659	10.957375
22	9.043762	9.997327	9.046434	10.953566	10.002673	10.956238
23	9.044895	9.997313	9.047582	10.952418	10.002687	10.955105
24	9.046026	9.997299	9.048727	10.951273	10.002701	10.953974
25	9.047154	9.997285	9.049869	10.950131	10.002715	10.952846
26	9.048279	9.997271	9.051008	10.948992	10.002729	10.951721
27	9.049400	9.997257	9.052144	10.947856	10.002743	10.950599
28	9.050519	9.997242	9.053277	10.946723	10.002758	10.949481
29	9.051635	9.997228	9.054402	10.945593	10.002772	10.948365
30	9.052748	9.997214	9.055535	10.944465	10.002786	10.947251
31	9.053850	9.997199	9.056659	10.943340	10.002801	10.946141
	Sine.		Tang.		Secant.	

83 Degrees.

Tangents and Secants.

439

6 Degrees :

Min.	Sine.		Tang.		Secant.		Min.
30	9.053859	9.997199	9.056659	10.947340	10.002801	10.946141	30
31	9.054966	9.997185	9.057781	10.942219	10.002815	10.945034	29
32	9.056071	9.997170	9.058900	10.941100	10.002830	10.943929	28
33	9.057172	9.997156	9.060016	10.939984	10.002844	10.942828	27
34	9.058271	9.997141	9.061130	10.938870	10.002859	10.941729	26
35	9.059367	9.997127	9.062240	10.937760	10.002873	10.940633	25
36	9.060460	9.997112	9.063348	10.936652	10.002888	10.939540	24
37	9.061551	9.997098	9.064453	10.935547	10.002902	10.938449	23
38	9.062639	9.997083	9.065556	10.934444	10.002917	10.937361	22
39	9.063723	9.997068	9.066655	10.933345	10.002932	10.936276	21
40	9.064806	9.997053	9.067752	10.932248	10.002946	10.935196	20
41	9.065885	9.997039	9.068846	10.931153	10.002961	10.934115	19
42	9.066962	9.997024	9.069938	10.930062	10.002976	10.933038	18
43	9.068036	9.997009	9.071027	10.928973	10.002991	10.931964	17
44	9.069107	9.996994	9.072113	10.927887	10.003006	10.930893	16
45	9.070176	9.996979	9.073197	10.926803	10.003021	10.929824	15
46	9.071242	9.996964	9.074278	10.925722	10.003036	10.928758	14
47	9.072305	9.996949	9.075356	10.924644	10.003051	10.927694	13
48	9.073366	9.996934	9.076432	10.923568	10.003066	10.926634	12
49	9.074424	9.996919	9.077505	10.922495	10.003081	10.925576	11
50	9.075480	9.996904	9.078576	10.921424	10.003096	10.924520	10
51	9.076533	9.996889	9.079644	10.920356	10.003111	10.923467	9
52	9.077583	9.996874	9.080710	10.919290	10.003126	10.922417	8
53	9.078631	9.996858	9.081773	10.918227	10.003142	10.921369	7
54	9.079676	9.996843	9.082833	10.917167	10.003157	10.920324	6
55	9.080719	9.996828	9.083891	10.916109	10.003172	10.919281	5
56	9.081759	9.996812	9.084947	10.915053	10.003187	10.918241	4
57	9.082797	9.996797	9.085000	10.914000	10.003203	10.917203	3
58	9.083832	9.996782	9.087050	10.912950	10.003218	10.916168	2
59	9.084864	9.996766	9.088098	10.911902	10.003234	10.915136	1
60	9.085894	9.996751	9.089144	10.910856	10.003249	10.914105	0
	Sine.		Tang.		Secant.		Min.

83 Degrees.

G B 4

7 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.085894	9.996751	9.089144	10.910856	10.003249	10.914105
1	9.086922	9.996735	9.090187	10.909813	10.003265	10.913078
2	9.087947	9.996720	9.091228	10.908772	10.003280	10.912053
3	9.088970	9.996704	9.092266	10.907734	10.003296	10.911030
4	9.089990	9.996688	9.093302	10.906698	10.003312	10.910010
5	9.091008	9.996672	9.094335	10.905664	10.003327	10.908992
6	9.092024	9.996657	9.095367	10.904633	10.003343	10.907976
7	9.093037	9.996641	9.096395	10.903604	10.003359	10.906963
8	9.094047	9.996625	9.097422	10.902578	10.003375	10.905953
9	9.095056	9.996610	9.098446	10.901554	10.003390	10.904944
10	9.096061	9.996594	9.099468	10.900532	10.003406	10.903938
11	9.097065	9.996578	9.100487	10.899512	10.003422	10.902934
12	9.098066	9.996562	9.101504	10.898496	10.003438	10.901934
13	9.099065	9.996545	9.102519	10.897481	10.003454	10.900935
14	9.100062	9.996530	9.103532	10.896468	10.003470	10.899938
15	9.101050	9.996514	9.104542	10.895458	10.003486	10.898944
16	9.102048	9.996498	9.105550	10.894450	10.003502	10.897952
17	9.103037	9.996482	9.106556	10.893444	10.003518	10.896963
18	9.104035	9.996465	9.107559	10.892441	10.003534	10.895975
19	9.105010	9.996449	9.108560	10.891440	10.003551	10.894990
20	9.105992	9.996433	9.109559	10.890441	10.003567	10.894008
21	9.106973	9.996417	9.110556	10.889444	10.003583	10.893027
22	9.107951	9.996400	9.111551	10.888449	10.003600	10.892049
23	9.108927	9.996384	9.112543	10.887457	10.003616	10.891073
24	9.109901	9.996368	9.113533	10.886467	10.003632	10.890099
25	9.110873	9.996351	9.114521	10.885479	10.003649	10.889127
26	9.111842	9.996335	9.115507	10.884493	10.003665	10.888158
27	9.112809	9.996318	9.116491	10.883509	10.003682	10.887191
28	9.113774	9.996302	9.117472	10.882528	10.003698	10.886226
29	9.114737	9.996285	9.118452	10.881548	10.003715	10.885263
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.884302
		Sine.		Tang.		Secant.

82 Degrees.

Tangents and Secants.

(441)

7 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.115098	9.996269	9.119429	10.880571	10.003731	10.884302	30
31	9.116656	9.996252	9.120404	10.879596	10.003748	10.883344	29
32	9.117612	9.996235	9.121377	10.878623	10.003765	10.882387	28
33	9.118567	9.996218	9.122348	10.877652	10.003781	10.881433	27
34	9.119519	9.996202	9.123317	10.876682	10.003798	10.880481	26
35	9.120469	9.996185	9.124284	10.875710	10.003815	10.879531	25
36	9.121417	9.996168	9.125249	10.874751	10.003832	10.878583	24
37	9.122362	9.996151	9.126211	10.873789	10.003849	10.877638	23
38	9.123306	9.996134	9.127172	10.872828	10.003866	10.876694	22
39	9.124248	9.996117	9.128130	10.871870	10.003883	10.875752	21
40	9.125187	9.996100	9.129087	10.870913	10.003900	10.874813	20
41	9.126125	9.996083	9.130041	10.869959	10.003917	10.873875	19
42	9.127060	9.996066	9.130994	10.869006	10.003934	10.872949	18
43	9.127993	9.996049	9.131944	10.868056	10.003951	10.872007	17
44	9.128925	9.996032	9.132893	10.867107	10.003968	10.871075	16
45	9.129854	9.996015	9.133839	10.866161	10.003985	10.870146	15
46	9.130781	9.995998	9.134783	10.865216	10.004002	10.869219	14
47	9.131706	9.995980	9.135726	10.864274	10.004020	10.868294	13
48	9.132630	9.995963	9.136666	10.863333	10.004037	10.867370	12
49	9.133551	9.995946	9.136905	10.862395	10.004054	10.866449	11
50	9.134470	9.995928	9.138542	10.861458	10.004072	10.865530	10
51	9.135387	9.995911	9.139476	10.860524	10.004089	10.864612	9
52	9.136303	9.995894	9.140409	10.859591	10.004106	10.863697	8
53	9.137216	9.995876	9.141340	10.858660	10.004124	10.862784	7
54	9.138127	9.995859	9.142269	10.857731	10.004141	10.861872	6
55	9.139037	9.995841	9.143196	10.856804	10.004159	10.860963	5
56	9.139944	9.995823	9.144121	10.855879	10.004176	10.860055	4
57	9.140850	9.995806	9.145044	10.854956	10.004194	10.859150	3
58	9.141754	9.995788	9.145965	10.854034	10.004212	10.858246	2
59	9.142655	9.995770	9.146885	10.853115	10.004229	10.857344	1
60	9.143555	9.995753	9.147802	10.852197	10.004247	10.856445	0
	Sine.		Tang.		Secant.		Min.

82 Degrees.

8 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.143555	9.995753	9.147802	10.852197	10.004247	10.856445
1	9.144453	9.995735	9.148718	10.851282	10.004265	10.855547
2	9.145349	9.995717	9.149632	10.850368	10.004283	10.854651
3	9.146243	9.995699	9.150544	10.849456	10.004301	10.853756
4	9.147136	9.995681	9.151454	10.848546	10.004318	10.852864
5	9.148026	9.995663	9.152363	10.847637	10.004336	10.851974
6	9.148915	9.995646	9.153269	10.846731	10.004354	10.851085
7	9.149801	9.995628	9.154174	10.845826	10.004372	10.850198
8	9.150686	9.995609	9.155077	10.844923	10.004390	10.849314
9	9.151569	9.995591	9.155978	10.844022	10.004408	10.848431
10	9.152451	9.995573	9.156877	10.843123	10.004427	10.847549
11	9.153330	9.995555	9.157775	10.842225	10.004445	10.846670
12	9.154208	9.995537	9.158671	10.841329	10.004463	10.845792
13	9.155083	9.995519	9.159565	10.840435	10.004481	10.844917
14	9.155977	9.995500	9.160457	10.839543	10.004499	10.844043
15	9.156830	9.995482	9.161347	10.838653	10.004518	10.843170
16	9.157700	9.995464	9.162236	10.837764	10.004536	10.842300
17	9.158569	9.995445	9.163123	10.836877	10.004554	10.841431
18	9.159435	9.995427	9.164008	10.835992	10.004573	10.840565
19	9.160300	9.995409	9.164892	10.835108	10.004591	10.839699
20	9.161164	9.995390	9.165774	10.834226	10.004610	10.838836
21	9.162025	9.995372	9.166654	10.833346	10.004628	10.837974
22	9.162885	9.995353	9.167532	10.832468	10.004647	10.837115
23	9.163743	9.995334	9.168409	10.831591	10.004665	10.836257
24	9.164600	9.995316	9.169284	10.830716	10.004684	10.835400
25	9.165454	9.995297	9.170157	10.829843	10.004703	10.834546
26	9.166307	9.995278	9.171029	10.828971	10.004721	10.833693
27	9.167159	9.995260	9.171899	10.828101	10.004740	10.832841
28	9.168008	9.995241	9.172767	10.827233	10.004759	10.831992
29	9.168856	9.995222	9.173634	10.826366	10.004778	10.831144
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298
	Sine.		Tang.		Secant.	Min.

81 Degrees.

Tangents and Secants.

(443)

8 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.169702	9.995203	9.174499	10.825501
31	9.170546	9.995184	9.175362	10.824638
32	9.171389	9.995165	9.176224	10.823776
33	9.172230	9.995146	9.177084	10.822916
34	9.173070	9.995127	9.177942	10.822057
35	9.173908	9.995108	9.178799	10.821201
36	9.174744	9.995089	9.179655	10.820345
37	9.175578	9.995070	9.180508	10.819492
38	9.176411	9.995051	9.181360	10.818640
39	9.177242	9.995032	9.182211	10.817789
40	9.178072	9.995012	9.183059	10.816940
41	9.178900	9.994993	9.183907	10.816093
42	9.179726	9.994974	9.184752	10.815247
43	9.180551	9.994955	9.185597	10.814403
44	9.181374	9.994935	9.186439	10.813561
45	9.182196	9.994916	9.187280	10.812720
46	9.183016	9.994896	9.188120	10.811880
47	9.183834	9.994877	9.188957	10.811042
48	9.184651	9.994857	9.189794	10.810206
49	9.185466	9.994838	9.190629	10.809371
50	9.186280	9.994818	9.191462	10.808538
51	9.187092	9.994798	9.192294	10.807706
52	9.187902	9.994779	9.193124	10.806876
53	9.188712	9.994759	9.193953	10.806047
54	9.189519	9.994739	9.194780	10.805220
55	9.190325	9.994719	9.195606	10.804394
56	9.191130	9.994700	9.196430	10.803570
57	9.191933	9.994680	9.197253	10.802747
58	9.192734	9.994660	9.198074	10.801926
59	9.193534	9.994640	9.198894	10.801106
60	9.194332	9.994620	9.199712	10.800287
	Sine.	Tang.	Secant.	

81 Degrees.

9 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.194532	9.994620	9.199712	10.800287	10.005380	10.805698
1	9.195129	9.994600	9.200529	10.799471	10.005400	10.804871
2	9.195925	9.994580	9.201345	10.798655	10.005420	10.804075
3	9.196719	9.994560	9.202159	10.797841	10.005440	10.803281
4	9.197511	9.994540	9.202971	10.797029	10.005460	10.802489
5	9.198302	9.994519	9.203782	10.796217	10.005481	10.801698
6	9.199091	9.994499	9.204592	10.795408	10.005501	10.800909
7	9.199879	9.994479	9.205400	10.794600	10.005521	10.800121
8	9.200666	9.994459	9.206207	10.793793	10.005541	10.799334
9	9.201451	9.994438	9.207013	10.792987	10.005562	10.798549
10	9.202234	9.994418	9.207816	10.792183	10.005582	10.797765
11	9.203017	9.994397	9.208619	10.791381	10.005602	10.796983
12	9.203797	9.994377	9.209420	10.790580	10.005623	10.796203
13	9.204577	9.994357	9.210220	10.789780	10.005643	10.795423
14	9.205354	9.994336	9.211018	10.788982	10.005664	10.794645
15	9.206131	9.994316	9.211815	10.788185	10.005684	10.793869
16	9.206906	9.994295	9.212611	10.787389	10.005705	10.793094
17	9.207679	9.994277	9.213405	10.786595	10.005725	10.792320
18	9.208452	9.994254	9.214198	10.785802	10.005746	10.791548
19	9.209222	9.994233	9.214989	10.785011	10.005767	10.790778
20	9.209992	9.994212	9.215779	10.784220	10.005788	10.790008
21	9.210760	9.994191	9.216568	10.783432	10.005809	10.789240
22	9.211526	9.994171	9.217356	10.782644	10.005829	10.788474
23	9.212291	9.994150	9.218142	10.781858	10.005850	10.787709
24	9.213055	9.994129	9.218926	10.781074	10.005871	10.786945
25	9.213818	9.994108	9.219710	10.780290	10.005892	10.786182
26	9.214579	9.994087	9.220492	10.779508	10.005913	10.785421
27	9.215338	9.994066	9.221272	10.778728	10.005934	10.784662
28	9.216097	9.994045	9.222052	10.777948	10.005955	10.783903
29	9.216854	9.994024	9.222830	10.777170	10.005976	10.783146
30	9.217600	9.994003	9.223606	10.776392	10.005997	10.782391
	Sine.		Tang.		Secant.	Min.

80 Degrees.

Tangents and Secants.

(445)

9 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.217609	9.994003	9.223636	10.776393	10.005997	10.782391
31	9.218363	9.993981	9.224382	10.775618	10.006018	10.781636
32	9.219116	9.993960	9.225156	10.774844	10.006040	10.780884
33	9.219868	9.993939	9.225929	10.774071	10.006061	10.780132
34	9.220618	9.993918	9.226700	10.773300	10.006082	10.779382
35	9.221367	9.993896	9.227471	10.772529	10.006103	10.778633
36	9.222115	9.993875	9.228239	10.771760	10.006125	10.777885
37	9.222861	9.993854	9.229007	10.770993	10.006146	10.777139
38	9.223606	9.993832	9.229773	10.770226	10.006168	10.776394
39	9.224349	9.993811	9.230539	10.769461	10.006189	10.775650
40	9.225092	9.993789	9.231302	10.768698	10.006211	10.774908
41	9.225833	9.993768	9.232065	10.767935	10.006232	10.774167
42	9.226572	9.993746	9.232826	10.767174	10.006254	10.773427
43	9.227311	9.993725	9.233586	10.766414	10.006275	10.772689
44	9.228048	9.993703	9.234345	10.765655	10.006297	10.771952
45	9.228784	9.993681	9.235103	10.764897	10.006319	10.771216
46	9.229518	9.993660	9.235859	10.764141	10.006340	10.770481
47	9.230252	9.993638	9.236614	10.763386	10.006362	10.769748
48	9.230984	9.993616	9.237368	10.762632	10.006384	10.769016
49	9.231714	9.993594	9.238120	10.761880	10.006406	10.768285
50	9.232444	9.993572	9.238872	10.761128	10.006428	10.767556
51	9.233172	9.993550	9.239622	10.760378	10.006450	10.766828
52	9.233899	9.993528	9.240371	10.759629	10.006471	10.766101
53	9.234625	9.993506	9.241118	10.758881	10.006493	10.765375
54	9.235349	9.993484	9.241865	10.758135	10.006516	10.764651
55	9.236073	9.993462	9.242610	10.757390	10.006538	10.763927
56	9.236795	9.993440	9.243354	10.756646	10.006560	10.763205
57	9.237515	9.993418	9.244097	10.755903	10.006582	10.762485
58	9.238235	9.993396	9.244839	10.755161	10.006604	10.761765
59	9.238953	9.993374	9.245579	10.754421	10.006626	10.761047
60	9.239670	9.993351	9.246319	10.753681	10.006648	10.760330
		Sine.		Tang.		Secant.

80 Degrees.

10 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.239670	9.993351	9.246391	10.753681	10.006648	10.760330
1	9.240386	9.993329	9.247057	10.752943	10.006671	10.759614
2	9.241101	9.993307	9.247794	10.752206	10.006693	10.758899
3	9.241814	9.993284	9.248530	10.751470	10.006715	10.758186
4	9.242526	9.993262	9.249264	10.750736	10.006738	10.757474
5	9.243237	9.993240	9.249998	10.750002	10.006760	10.756763
6	9.243947	9.993217	9.250730	10.749270	10.006783	10.756053
7	9.244656	9.993195	9.251461	10.748539	10.006805	10.755344
8	9.245363	9.993172	9.252191	10.747809	10.006828	10.754637
9	9.246069	9.993149	9.252920	10.747080	10.006851	10.753930
10	9.246775	9.993127	9.253648	10.746352	10.006873	10.753225
11	9.247478	9.993104	9.254374	10.745626	10.006896	10.752522
12	9.248181	9.993081	9.255100	10.744900	10.006919	10.751819
13	9.248883	9.993059	9.255824	10.744176	10.006941	10.751117
14	9.249583	9.993036	9.256547	10.743453	10.006964	10.750417
15	9.250282	9.993013	9.257269	10.742731	10.006987	10.749718
16	9.250980	9.992990	9.257990	10.742010	10.007010	10.749020
17	9.251677	9.992967	9.258710	10.741290	10.007033	10.748323
18	9.252373	9.992944	9.259428	10.740571	10.007056	10.747627
19	9.253067	9.992921	9.260146	10.739854	10.007079	10.746932
20	9.253761	9.992898	9.260862	10.739137	10.007102	10.746239
21	9.254453	9.992875	9.261578	10.738422	10.007125	10.745547
22	9.255144	9.992852	9.262292	10.737708	10.007148	10.744856
23	9.255834	9.992829	9.263005	10.736995	10.007171	10.744166
24	9.256523	9.992806	9.263717	10.736283	10.007194	10.743477
25	9.257211	9.992783	9.264428	10.735572	10.007217	10.742789
26	9.257898	9.992759	9.265138	10.734862	10.007240	10.742102
27	9.258583	9.992736	9.265847	10.734153	10.007264	10.741417
28	9.259268	9.992713	9.266555	10.733445	10.007287	10.740732
29	9.259951	9.992689	9.267261	10.732739	10.007310	10.740049
30	9.260632	9.992666	9.267967	10.732033	10.007334	10.739367
		Sine.		Tang.		Secant.

79 Degrees.

Tangents and Secants.

(447)

10 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
31	9.261314	9.992643	9.268671	10.731329	10.007357	10.738686	29
32	9.261994	9.992619	9.269375	10.730625	10.007381	10.738076	28
33	9.262673	9.992596	9.270077	10.729923	10.007404	10.737327	27
34	9.263353	9.992572	9.270779	10.729221	10.007428	10.736649	26
35	9.264027	9.992549	9.271479	10.728521	10.007451	10.735973	25
36	9.264703	9.992525	9.272178	10.727822	10.007475	10.735297	24
37	9.265377	9.992501	9.272876	10.727124	10.007499	10.734622	23
38	9.266051	9.992478	9.273573	10.726427	10.007522	10.733949	22
39	9.266723	9.992454	9.274269	10.725731	10.007546	10.733276	21
40	9.267394	9.992430	9.274964	10.725036	10.007570	10.732605	20
41	9.268065	9.992406	9.275658	10.724342	10.007594	10.731935	19
42	9.268734	9.992382	9.276351	10.723649	10.007618	10.731266	18
43	9.269402	9.992358	9.277043	10.722957	10.007641	10.730598	17
44	9.270069	9.992335	9.277734	10.722266	10.007665	10.729931	16
45	9.270735	9.992311	9.278424	10.721576	10.007689	10.729265	15
46	9.271400	9.992287	9.279113	10.720887	10.007713	10.728600	14
47	9.272063	9.992263	9.279801	10.720199	10.007737	10.727936	13
48	9.272726	9.992238	9.280488	10.719512	10.007761	10.727274	12
49	9.273388	9.992214	9.281174	10.718826	10.007786	10.726612	11
50	9.274049	9.992190	9.281858	10.718141	10.007810	10.725951	10
51	9.274708	9.992166	9.282542	10.717458	10.007834	10.725292	9
52	9.275367	9.992142	9.283225	10.716775	10.007858	10.724633	8
53	9.276024	9.992117	9.283907	10.716093	10.007882	10.723975	7
54	9.276681	9.992093	9.284588	10.715412	10.007907	10.723319	6
55	9.277337	9.992069	9.285268	10.714732	10.007931	10.722663	5
56	9.277991	9.992044	9.285947	10.714053	10.007955	10.722009	4
57	9.278644	9.992020	9.286624	10.713375	10.007980	10.721355	3
58	9.279297	9.991996	9.287301	10.712699	10.008004	10.720703	2
59	9.279948	9.991971	9.287977	10.712023	10.008029	10.720052	1
60	0.280590	9.991947	9.288652	10.711348	10.008053	10.719401	0
	Sine.		Tang.		Secant.		Min.

79 Degrees.

11 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401
1	9.281248	9.991922	9.289236	10.710674	10.008078	10.718752
2	9.281897	9.991897	9.289999	10.710001	10.008103	10.718102
3	9.282544	9.991873	9.290671	10.709329	10.008127	10.717456
4	9.283290	9.991848	9.291342	10.708658	10.008152	10.716809
5	9.283830	9.991823	9.292013	10.707987	10.008177	10.716164
6	9.284480	9.991799	9.292682	10.707318	10.008201	10.715520
7	9.285124	9.991774	9.293350	10.706650	10.008226	10.714876
8	9.285766	9.991749	9.294017	10.705983	10.008251	10.714234
9	9.286408	9.991724	9.294684	10.705316	10.008275	10.713592
10	9.287048	9.991699	9.295349	10.704651	10.008301	10.712952
11	9.287687	9.991674	9.296013	10.703987	10.008326	10.712312
12	9.288326	9.991649	9.296677	10.703323	10.008351	10.711674
13	9.288964	9.991624	9.297339	10.702660	10.008376	10.711036
14	9.289600	9.991599	9.298001	10.701999	10.008401	10.710400
15	9.290230	9.991574	9.298662	10.701338	10.008426	10.709764
16	9.290870	9.991549	9.299322	10.700678	10.008451	10.709130
17	9.291504	9.991524	9.299980	10.700020	10.008476	10.708496
18	9.292137	9.991498	9.300638	10.699362	10.008502	10.707863
19	9.292768	9.991473	9.301295	10.698705	10.008527	10.707231
20	9.293399	9.991448	9.301951	10.698049	10.008552	10.706601
21	9.294029	9.991422	9.302607	10.697393	10.008577	10.705971
22	9.294658	9.991397	9.303261	10.696739	10.008603	10.705342
23	9.295286	9.991372	9.303914	10.696086	10.008628	10.704714
24	9.295913	9.991346	9.304567	10.695422	10.008654	10.704087
25	9.296539	9.991321	9.305218	10.694782	10.008679	10.703461
26	9.297164	9.991295	9.305869	10.694131	10.008705	10.702836
27	9.297788	9.991270	9.306519	10.693481	10.008730	10.702212
28	9.298412	9.991244	9.307167	10.692832	10.008756	10.701588
29	9.299034	9.991218	9.307815	10.692184	10.008782	10.700966
30	9.299655	9.991193	9.308463	10.691527	10.008807	10.700345
		Sine.		Tang.		Secant.

78 Degrees.

Tangents and Secants.

449

11 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.299655	9.991193	9.308488	10.691537	10.008807	10.700345
31	9.300276	9.991167	9.309109	10.690891	10.008823	10.699724
32	9.300895	9.991141	9.309754	10.690246	10.008859	10.699105
33	9.301514	9.991115	9.310398	10.689601	10.008885	10.698486
34	9.302132	9.991090	9.311042	10.688958	10.008910	10.697868
35	9.302748	9.991064	9.311685	10.688315	10.008936	10.697251
36	9.303364	9.991038	9.312327	10.687673	10.008962	10.696636
37	9.303979	9.991012	9.312967	10.687032	10.008988	10.696021
38	9.304593	9.990986	9.313608	10.686392	10.009014	10.695407
39	9.305207	9.990960	9.314247	10.685753	10.009041	10.694793
40	9.305819	9.990934	9.314885	10.685115	10.009066	10.694181
41	9.306430	9.990908	9.315523	10.684477	10.009092	10.693570
42	9.307041	9.990881	9.316159	10.683841	10.009118	10.692959
43	9.307650	9.990855	9.316795	10.683205	10.009145	10.692350
44	9.308259	9.990829	9.317430	10.682570	10.009171	10.691741
45	9.308867	9.990803	9.318064	10.681936	10.009197	10.691133
46	9.309474	9.990777	9.318697	10.681303	10.009223	10.690526
47	9.310080	9.990750	9.319329	10.680670	10.009250	10.689920
48	9.310685	9.990724	9.319961	10.680039	10.009276	10.689315
49	9.311289	9.990697	9.320592	10.679408	10.009303	10.688711
50	9.311893	9.990671	9.321222	10.678778	10.009329	10.688107
51	9.312495	9.990644	9.321851	10.678149	10.009355	10.687505
52	9.313097	9.990618	9.322479	10.677521	10.009382	10.686903
53	9.313698	9.990591	9.323106	10.676894	10.009409	10.686302
54	9.314297	9.990565	9.323733	10.676267	10.009435	10.685702
55	9.314896	9.990538	9.324358	10.675642	10.009462	10.685103
56	9.315495	9.990511	9.324983	10.675017	10.009488	10.684505
57	9.316092	9.990485	9.325607	10.674393	10.009515	10.683908
58	9.316688	9.990458	9.326230	10.673769	10.009542	10.683311
59	9.317284	9.990431	9.326853	10.673147	10.009569	10.682716
60	9.317879	9.990404	9.327474	10.672525	10.009596	10.682121
		Sine.		Tang.		Secant.
						Min.

78 Degrees.

H h

12 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.317879	9.990464	9.327474	10.672525	10.009596	10.682121
1	9.318473	9.990377	9.328095	10.671905	10.009622	10.681527
2	9.319066	9.990351	9.328715	10.671285	10.009649	10.680934
3	9.319658	9.990324	9.329334	10.670665	10.009676	10.680342
4	9.320249	9.990297	9.329953	10.670047	10.009703	10.679750
5	9.320840	9.990270	9.330570	10.66943	10.009730	10.679160
6	9.321430	9.990243	9.331187	10.668813	10.009757	10.678570
7	9.322019	9.990215	9.331803	10.668197	10.009784	10.677981
8	9.322607	9.990188	9.332418	10.667582	10.009812	10.677393
9	9.323194	9.990161	9.333033	10.666967	10.009839	10.676806
10	9.323780	9.990134	9.333646	10.666354	10.009866	10.676220
11	9.324366	9.990107	9.334259	10.665741	10.009893	10.675634
12	9.324950	9.990079	9.334871	10.665129	10.009921	10.675049
13	9.325534	9.990052	9.335482	10.664518	10.009948	10.674466
14	9.326117	9.990025	9.336093	10.663907	10.009975	10.673883
15	9.326700	9.989997	9.336702	10.663297	10.010003	10.673300
16	9.327281	9.989970	9.337311	10.662689	10.010030	10.672719
17	9.327862	9.989942	9.337919	10.662081	10.010058	10.672138
18	9.328442	9.989915	9.338527	10.661473	10.010085	10.671558
19	9.329021	9.989887	9.339133	10.660867	10.010113	10.670979
20	9.329599	9.989860	9.339739	10.660261	10.010140	10.670401
21	9.330176	9.989832	9.340344	10.659656	10.010169	10.669824
22	9.330735	9.989804	9.340948	10.659052	10.010196	10.669247
23	9.331328	9.989777	9.341552	10.658448	10.010223	10.668671
24	9.331903	9.989749	9.342155	10.657845	10.010251	10.668096
25	9.332478	9.989721	9.342757	10.657243	10.010279	10.667523
26	9.333051	9.989693	9.343358	10.656642	10.010307	10.666949
27	9.333624	9.989665	9.343958	10.656042	10.010335	10.666376
28	9.334195	9.989637	9.344558	10.655442	10.010363	10.665804
29	9.334766	9.989609	9.345157	10.654843	10.010391	10.665233
30	9.335337	9.989581	9.345755	10.654245	10.010418	10.664663
	Sine.		Tang.		Secant.	

77 Degrees.

Tangents and Secants.

451

12 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.335337	9.989581	9.345755	10.654245
31	9.335906	9.989553	9.346353	10.653647
32	9.336475	9.989525	9.346949	10.653051
33	9.337043	9.989497	9.347545	10.652455
34	9.337610	9.989469	9.348141	10.651859
35	9.338176	9.989441	9.348735	10.651265
36	9.338742	9.989413	9.349329	10.650671
37	9.339306	9.989384	9.349922	10.650078
38	9.339871	9.989356	9.350514	10.649486
39	9.340434	9.989328	9.351106	10.648894
40	9.340996	9.989299	9.351697	10.648303
41	9.341558	9.989271	9.352287	10.647713
42	9.342119	9.989243	9.352876	10.647124
43	9.342679	9.989214	9.353465	10.646535
44	9.343239	9.989186	9.354053	10.645947
45	9.343797	9.989157	9.354640	10.645360
46	9.344355	9.989128	9.355227	10.644773
47	9.344912	9.989100	9.355813	10.644187
48	9.345469	9.989071	9.356398	10.643602
49	9.346024	9.989042	9.356982	10.643018
50	9.346579	9.989014	9.357566	10.642434
51	9.347134	9.988985	9.358149	10.641851
52	9.347687	9.988956	9.358731	10.641269
53	9.348240	9.988927	9.359313	10.640687
54	9.348792	9.988898	9.359893	10.640106
55	9.349343	9.988869	9.360474	10.639526
56	9.349893	9.988840	9.361053	10.638947
57	9.350443	9.988811	9.361632	10.638368
58	9.350992	9.988782	9.362210	10.637790
59	9.351540	9.988753	9.362787	10.637213
60	9.352088	9.988724	9.363364	10.636636
	Sine.	Tang.	Secant.	Min.

77 Degrees.

H h 2

13 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.352088	9.988724	9.363304	10.636636	10.011276	10.647912
1	9.352635	9.988685	9.363940	10.636060	10.011305	10.647365
2	9.353181	9.988665	9.364515	10.635484	10.011334	10.646819
3	9.353726	9.988636	9.365090	10.634910	10.011364	10.646274
4	9.354271	9.988607	9.365664	10.634336	10.011393	10.645729
5	9.354815	9.988578	9.366237	10.633763	10.011422	10.645185
6	9.355358	9.988548	9.366810	10.633190	10.011452	10.644642
7	9.355901	9.988519	9.367382	10.632618	10.011481	10.644099
8	9.356443	9.988489	9.367953	10.632047	10.011511	10.643557
9	9.356984	9.988460	9.368524	10.631476	10.011540	10.643016
10	9.357524	9.988430	9.369094	10.630906	10.011570	10.642476
11	9.358064	9.988401	9.369663	10.630337	10.011599	10.641936
12	9.358603	9.988371	9.370231	10.629768	10.011629	10.641397
13	9.359141	9.988341	9.370799	10.629201	10.011658	10.640859
14	9.359678	9.988312	9.371367	10.628633	10.011688	10.640321
15	9.360215	9.988282	9.371933	10.628067	10.011718	10.639785
16	9.360751	9.988252	9.372499	10.627501	10.011748	10.639248
17	9.361287	9.988222	9.373064	10.626935	10.011777	10.638713
18	9.361822	9.988193	9.373629	10.626371	10.011807	10.638178
19	9.362356	9.988163	9.374193	10.625807	10.011837	10.637644
20	9.362889	9.988133	9.374756	10.625244	10.011867	10.637111
21	9.363422	9.988103	9.375319	10.624681	10.011897	10.636578
22	9.363954	9.988073	9.375881	10.624119	10.011927	10.636046
23	9.364485	9.988043	9.376442	10.623558	10.011957	10.635515
24	9.365016	9.988013	9.377003	10.622997	10.011987	10.634984
25	9.365546	9.987983	9.377563	10.622437	10.012017	10.634454
26	9.366075	9.987952	9.378122	10.621877	10.012047	10.633925
27	9.366604	9.987922	9.378681	10.621319	10.012078	10.633396
28	9.367131	9.987892	9.379239	10.620761	10.012108	10.632868
29	9.367655	9.987862	9.379797	10.620203	10.012138	10.632341
30	9.368185	9.987831	9.380354	10.619646	10.012168	10.631815
	Sine.		Tang.		Secant.	

76 Degrees.

Tangents and Secants.

453

13 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.368185	9.987831	9.380354	10.619646	10.012168	10.631815	30
31	9.368711	9.987801	9.380910	10.619090	10.012199	10.631289	29
32	9.369236	9.987771	9.381465	10.618534	10.012229	10.630764	28
33	9.369761	9.987740	9.382020	10.617979	10.012260	10.630239	27
34	9.370285	9.987710	9.382575	10.617425	10.012290	10.629715	26
35	9.370808	9.987679	9.383128	10.616871	10.012321	10.629192	25
36	9.371330	9.987649	9.383682	10.616318	10.012351	10.628670	24
37	9.371852	9.987618	9.384234	10.615766	10.012382	10.628148	23
38	9.372373	9.987588	9.384786	10.615214	10.012412	10.627626	22
39	9.372894	9.987557	9.385337	10.614663	10.012443	10.627106	21
40	9.373414	9.987526	9.385888	10.614112	10.012474	10.626586	20
41	9.373933	9.987495	9.386438	10.613562	10.012504	10.626067	19
42	9.374452	9.987465	9.386987	10.613013	10.012535	10.625548	18
43	9.374970	9.987434	9.387536	10.612464	10.012566	10.625030	17
44	9.375487	9.987403	9.388084	10.611916	10.012597	10.624513	16
45	9.376003	9.987372	9.388631	10.611369	10.012628	10.623997	15
46	9.376519	9.987341	9.389178	10.610822	10.012659	10.623481	14
47	9.377035	9.987310	9.389724	10.610276	10.012690	10.622965	13
48	9.377549	9.987279	9.390270	10.609730	10.012721	10.622451	12
49	9.378063	9.987248	9.390815	10.609185	10.012752	10.621937	11
50	9.378577	9.987217	9.391359	10.608640	10.012783	10.621423	10
51	9.379089	9.987186	9.391903	10.608097	10.012814	10.620911	9
52	9.379601	9.987155	9.392447	10.607553	10.012845	10.620398	8
53	9.380113	9.987124	9.392989	10.607011	10.012876	10.619887	7
54	9.380624	9.987092	9.393531	10.606449	10.012908	10.619376	6
55	9.381134	9.987061	9.394073	10.605927	10.012939	10.618866	5
56	9.381643	9.987030	9.394614	10.605388	10.012970	10.618357	4
57	9.382152	9.986998	9.395154	10.604846	10.013002	10.617848	3
58	9.382660	9.986967	9.395693	10.604306	10.013033	10.617339	2
59	9.383168	9.986936	9.396233	10.603767	10.013064	10.616832	1
60	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	0
	Sine.		Tang.		Secant.		Min.

76 Degrees.

H h 3

14 Degrees.

Min.	Sine.		Tang		Secant.	
0	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325
1	9.384181	9.986873	9.397309	10.602691	10.013127	10.615818
2	9.384687	9.986841	9.397846	10.602154	10.013159	10.615313
3	9.385192	9.986809	9.398383	10.601617	10.013191	10.614808
4	9.385697	9.986778	9.398919	10.601081	10.013222	10.614303
5	9.386201	9.986746	9.399455	10.600540	10.013254	10.613799
6	9.386704	9.986714	9.399990	10.600005	10.013286	10.613296
7	9.387207	9.986683	9.400524	10.599476	10.013317	10.612793
8	9.387709	9.986651	9.401058	10.598942	10.013349	10.612291
9	9.388210	9.986619	9.401591	10.598409	10.013381	10.611790
10	9.388711	9.986587	9.402124	10.597876	10.013413	10.611289
11	9.389211	9.986555	9.402656	10.597344	10.013445	10.610789
12	9.389711	9.986523	9.403187	10.596813	10.013477	10.610289
13	9.390210	9.986491	9.403718	10.596282	10.013509	10.609790
14	9.390708	9.986459	9.404249	10.595751	10.013541	10.609292
15	9.391206	9.986427	9.404778	10.595222	10.013573	10.608794
16	9.391703	9.986395	9.405308	10.594692	10.013605	10.608297
17	9.392199	9.986363	9.405836	10.594164	10.013637	10.607801
18	9.392695	9.986331	9.406364	10.593636	10.013669	10.607305
19	9.393190	9.986299	9.406892	10.593108	10.013701	10.606809
20	9.393685	9.986266	9.407419	10.592581	10.013734	10.606315
21	9.394179	9.986234	9.407945	10.592055	10.013766	10.605821
22	9.394673	9.986202	9.408471	10.591529	10.013798	10.605327
23	9.395166	9.986169	9.408996	10.591003	10.013831	10.604834
24	9.395658	9.986137	9.409521	10.590479	10.013863	10.604342
25	9.396150	9.986104	9.410045	10.589955	10.013895	10.603850
26	9.396641	9.986072	9.410569	10.589431	10.013928	10.603359
27	9.397131	9.986039	9.411092	10.588908	10.013961	10.602863
28	9.397621	9.986007	9.411615	10.588385	10.013993	10.602378
29	9.398111	9.985974	9.412137	10.587863	10.014025	10.601889
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400
		Sine.		Tang.		Secant.

75 Degrees.

Tangents and Secants.

455

14 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.398600	9.985942	9.412658	10.587242	10.014058	10.601400	30
31	9.399088	9.985909	9.413179	10.586821	10.014091	10.600912	29
32	9.399575	9.985876	9.413699	10.586301	10.014124	10.600425	28
33	9.400062	9.985843	9.414219	10.585781	10.014157	10.599937	27
34	9.400540	9.985811	9.414738	10.585262	10.014189	10.599451	26
35	9.401035	9.985778	9.415257	10.584743	10.014222	10.598965	25
36	9.401526	9.985745	9.415775	10.584225	10.014255	10.598480	24
37	9.402005	9.985712	9.416293	10.583707	10.014288	10.597995	23
38	9.402489	9.985679	9.416810	10.583190	10.014321	10.597511	22
39	9.402973	9.985646	9.417326	10.582673	10.014354	10.597028	21
40	9.403455	9.985613	9.417842	10.582157	10.014387	10.596545	20
41	9.403938	9.985580	9.418358	10.581642	10.014420	10.596062	19
42	9.404420	9.985547	9.418873	10.581127	10.014453	10.595580	18
43	9.404901	9.985513	9.419387	10.580613	10.014485	10.595099	17
44	9.405382	9.985480	9.419901	10.580099	10.014520	10.594618	16
45	9.405862	9.985447	9.420415	10.579585	10.014553	10.594138	15
46	9.406341	9.985414	9.420927	10.579072	10.014586	10.593659	14
47	9.406820	9.985380	9.421440	10.578560	10.014619	10.593180	13
48	9.407299	9.985347	9.421951	10.578048	10.014653	10.592701	12
49	9.407777	9.985314	9.422462	10.577537	10.014686	10.592223	11
50	9.408254	9.985280	9.422973	10.577026	10.014720	10.591746	10
51	9.408737	9.985247	9.423484	10.576516	10.014753	10.591269	9
52	9.409204	9.985213	9.423993	10.576006	10.014787	10.590793	8
53	9.409682	9.985180	9.424503	10.575497	10.014820	10.590318	7
54	9.410157	9.985146	9.425011	10.574989	10.014854	10.589842	6
55	9.410532	9.985112	9.425519	10.574481	10.014887	10.589368	5
56	9.411106	9.985079	9.426027	10.573973	10.014921	10.588894	4
57	9.411579	9.985045	9.426534	10.573466	10.014955	10.588421	3
58	9.412052	9.985011	9.427041	10.572959	10.014989	10.587948	2
59	9.412524	9.984978	9.427547	10.572453	10.015022	10.587475	1
60	9.412996	9.984944	9.428052	10.571947	10.015056	10.587004	0
	Sine.		Tang.		Secant.		Min.

75 Degrees.

H h 4

15 Degrees.

Min.	Sine.		Tang		Secant.	
0	9.412996	9.984944	9.428052	10.571947	10.015056	10.587004
1	9.413467	9.984910	9.428557	10.571442	10.015090	10.586533
2	9.413938	9.984876	9.429062	10.570938	10.015124	10.586062
3	9.414408	9.984842	9.429566	10.570434	10.015158	10.585592
4	9.414878	9.984808	9.430070	10.569930	10.015192	10.585122
5	9.415347	9.984774	9.430573	10.569427	10.015226	10.584653
6	9.415815	9.984740	9.431075	10.568925	10.015260	10.584184
7	9.416283	9.984706	9.431577	10.568423	10.015294	10.583717
8	9.416751	9.984672	9.432079	10.567921	10.015328	10.583249
9	9.417217	9.984637	9.432580	10.567420	10.015352	10.582783
10	9.417684	9.984603	9.433080	10.566920	10.015397	10.582316
11	9.418149	9.984569	9.433580	10.566419	10.015431	10.581850
12	9.418615	9.984535	9.434080	10.565920	10.015465	10.581385
13	9.419079	9.984500	9.434579	10.565421	10.015500	10.580920
14	9.419544	9.984466	9.435078	10.564922	10.015534	10.580456
15	9.420007	9.984432	9.435576	10.564424	10.015568	10.579993
16	9.420470	9.984397	9.436073	10.563927	10.015603	10.579530
17	9.420933	9.984363	9.436570	10.563430	10.015637	10.579067
18	9.421395	9.984328	9.437067	10.562933	10.015672	10.578603
19	9.421857	9.984293	9.437563	10.562437	10.015706	10.578143
20	9.422318	9.984259	9.438059	10.561941	10.015741	10.577682
21	9.422778	9.984224	9.438554	10.561446	10.015776	10.577222
22	9.423238	9.984189	9.439048	10.560951	10.015810	10.576762
23	9.423697	9.984155	9.439543	10.560457	10.015845	10.576303
24	9.424156	9.984120	9.440036	10.559964	10.015880	10.575844
25	9.424615	9.984085	9.440529	10.559470	10.015915	10.575385
26	9.425073	9.984050	9.441022	10.558978	10.015950	10.574927
27	9.425530	9.984015	9.441514	10.558485	10.015985	10.574470
28	9.425987	9.983980	9.442006	10.557994	10.016019	10.574013
29	9.426443	9.983946	9.442497	10.557502	10.016054	10.573557
30	9.426899	9.983910	9.442988	10.557012	10.016089	10.573101
		Sine.		Tang.		Secant.

74 Degrees.

Tangents and Secants.

457

15 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.426899	9.983910	9.442988	10.557012	10.016089	10.573101	30
31	9.427354	9.983875	9.443479	10.556521	10.016124	10.572646	29
32	9.427809	9.983840	9.443968	10.556031	10.016160	10.572191	28
33	9.428263	9.983805	9.444458	10.555542	10.016195	10.571737	27
34	9.428717	9.983770	9.444947	10.555052	10.016230	10.571283	26
35	9.429170	9.983735	9.445435	10.554565	10.016265	10.570830	25
36	9.429623	9.983700	9.445923	10.554077	10.016300	10.570377	24
37	9.430075	9.983664	9.446411	10.553589	10.016336	10.569925	23
38	9.430527	9.983629	9.446898	10.553102	10.016371	10.569473	22
39	9.430978	9.983594	9.447384	10.552616	10.016406	10.569022	21
40	9.431429	9.983558	9.447870	10.552130	10.016442	10.568571	20
41	9.431879	9.983523	9.448356	10.551644	10.016477	10.568121	19
42	9.432328	9.983487	9.448841	10.551159	10.016513	10.567671	18
43	9.432778	9.983452	9.449326	10.550674	10.016548	10.567222	17
44	9.433226	9.983416	9.449810	10.550190	10.016584	10.566774	16
45	9.433675	9.983380	9.450294	10.549706	10.016619	10.566325	15
46	9.434122	9.983345	9.450777	10.549223	10.016655	10.565878	14
47	9.434569	9.983309	9.451260	10.548740	10.016691	10.565431	13
48	9.435016	9.983273	9.451743	10.548257	10.016726	10.564984	12
49	9.435462	9.983238	9.452225	10.547775	10.016762	10.564538	11
50	9.435908	9.983202	9.452706	10.547294	10.016798	10.564092	10
51	9.436353	9.983166	9.453187	10.546813	10.016834	10.563647	9
52	9.436798	9.983130	9.453668	10.546332	10.016870	10.563202	8
53	9.437242	9.983094	9.454148	10.545852	10.016906	10.562758	7
54	9.437686	9.983058	9.454628	10.545372	10.016942	10.562314	6
55	9.438129	9.983022	9.455107	10.544893	10.016978	10.561871	5
56	9.438572	9.982986	9.455586	10.544414	10.017014	10.561428	4
57	9.439014	9.982950	9.456064	10.543936	10.017050	10.560986	3
58	9.439456	9.982914	9.456542	10.543458	10.017086	10.560544	2
59	9.439897	9.982878	9.457019	10.542981	10.017122	10.560103	1
60	9.440338	9.982842	9.457406	10.542504	10.017158	10.559662	0
	Sine.		Tang.		Secant.		Min.

74 Degrees.

16 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.440338	9.982842	9.457490	10.542504	10.017158	10.559662
1	9.440778	9.982805	9.457973	10.542027	10.017195	10.559222
2	9.441218	9.982769	9.458449	10.541551	10.017231	10.558782
3	9.441658	9.982733	9.458925	10.541075	10.017267	10.558342
4	9.442096	9.982696	9.459400	10.540600	10.017304	10.557903
5	9.442535	9.982660	9.459875	10.540125	10.017340	10.559662
6	9.442973	9.982623	9.460349	10.539651	10.017376	10.559222
7	9.443410	9.982587	9.460823	10.539177	10.017413	10.558782
8	9.443847	9.982551	9.461297	10.538703	10.017449	10.558342
9	9.444284	9.982514	9.461770	10.538230	10.017486	10.557903
10	9.444720	9.982477	9.462242	10.537758	10.017523	10.555280
11	9.445155	9.982441	9.462714	10.537285	10.017559	10.554845
12	9.445590	9.982404	9.463186	10.536814	10.017596	10.554410
13	9.446025	9.982367	9.463658	10.536342	10.017633	10.553975
14	9.446450	9.982331	9.464128	10.535871	10.017669	10.553541
15	9.446873	9.982294	9.464599	10.535401	10.017706	10.553107
16	9.447326	9.982257	9.465069	10.534931	10.017743	10.552674
17	9.447759	9.982220	9.465539	10.534461	10.017780	10.552241
18	9.448191	9.982184	9.466008	10.533992	10.017817	10.551809
19	9.448623	9.982146	9.466476	10.533523	10.017854	10.551377
20	9.449054	9.982109	9.466945	10.533055	10.017891	10.550946
21	9.449285	9.982079	9.467413	10.532587	10.017928	10.550515
22	9.449915	9.982035	9.467880	10.532120	10.017965	10.550085
23	9.450345	9.981998	9.468347	10.531653	10.018002	10.549655
24	9.450775	9.981961	9.468814	10.531186	10.018039	10.549225
25	9.451204	9.981924	9.469280	10.530720	10.018076	10.548796
26	9.451632	9.981886	9.469746	10.530254	10.018114	10.548368
27	9.452060	9.981849	9.470211	10.529789	10.018151	10.547940
28	9.452488	9.981812	9.470676	10.529324	10.018188	10.547512
29	9.452915	9.981774	9.471141	10.528859	10.018226	10.547085
30	9.452342	9.981734	9.471605	10.528395	10.018263	10.546658
	Sine.		Tang.		Secant.	Min.

73 Degrees.

Tangents and Secants.

459

16 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.453342	9.981737	9.471605	10.528395
31	9.453768	9.981699	9.472068	10.527913
32	9.454194	9.981662	9.472532	10.527468
33	9.454619	9.981624	9.472995	10.527005
34	9.455044	9.981587	9.473457	10.526542
35	9.455469	9.981549	9.473919	10.526081
36	9.455893	9.981512	9.474381	10.525619
37	9.456316	9.981474	9.474842	10.525158
38	9.456739	9.981436	9.475303	10.524697
39	9.457162	9.981399	9.475793	10.524237
40	9.457584	9.981361	9.476223	10.523777
41	9.458006	9.981323	9.476683	10.523317
42	9.458427	9.981285	9.477142	10.522858
43	9.458848	9.981247	9.477601	10.522399
44	9.459268	9.981209	9.478059	10.521941
45	9.459688	9.981174	9.478517	10.521483
46	9.460108	9.981133	9.478975	10.521025
47	9.460527	9.981095	9.479422	10.520568
48	9.460946	9.981057	9.479889	10.520111
49	9.461364	9.981019	9.480345	10.519655
50	9.461782	9.980980	9.480801	10.519199
51	9.462199	9.980942	9.481257	10.518743
52	9.462616	9.980904	9.481712	10.518288
53	9.463032	9.980866	9.482167	10.517833
54	9.463448	9.980827	9.482621	10.517379
55	9.463864	9.980789	9.483075	10.516925
56	9.464275	9.980750	9.483529	10.516471
57	9.464694	9.980712	9.483982	10.516018
58	9.465108	9.980673	9.484435	10.515565
59	9.465522	9.980635	9.484887	10.515112
60	9.465935	9.980596	9.485339	10.514661
	Sine.	Tang.	Secant.	Min.

73 Degrees.

17 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.465935	9.980596	9.485339	10.514665	10.019404	10.534065
1	9.466348	9.980558	9.485791	10.514209	10.019442	10.533652
2	9.466761	9.980519	9.486242	10.513758	10.019481	10.533239
3	9.467173	9.980480	9.486693	10.513307	10.019520	10.532827
4	9.467585	9.980441	9.487143	10.512857	10.019558	10.532415
5	9.467996	9.980403	9.487593	10.512407	10.019597	10.532004
6	9.468407	9.980364	9.488043	10.511957	10.019636	10.531593
7	9.468817	9.980325	9.488492	10.511508	10.019675	10.531183
8	9.469227	9.980286	9.488941	10.511059	10.019714	10.530773
9	9.469637	9.980247	9.489390	10.510610	10.019753	10.530363
10	9.470046	9.980208	9.489838	10.510162	10.019792	10.529954
11	9.470455	9.980169	9.490286	10.509714	10.019831	10.529545
12	9.470863	9.980130	9.490733	10.509267	10.019870	10.529137
13	9.471271	9.980091	9.491180	10.508820	10.019909	10.528729
14	9.471678	9.980052	9.491627	10.508373	10.019948	10.528321
15	9.472086	9.980012	9.492073	10.507927	10.019988	10.527914
16	9.472492	9.979973	9.492519	10.507481	10.020027	10.527508
17	9.472898	9.979934	9.492965	10.507035	10.020066	10.527101
18	9.473304	9.979895	9.493410	10.506580	10.020105	10.526696
19	9.473710	9.979855	9.493854	10.506145	10.020145	10.526290
20	9.474115	9.979816	9.494299	10.505701	10.020184	10.525885
21	9.474519	9.979776	9.494743	10.505257	10.020224	10.525481
22	9.474923	9.979737	9.495186	10.504813	10.020263	10.525077
23	9.475327	9.979697	9.495630	10.504470	10.020303	10.524673
24	9.475730	9.979659	9.496073	10.503927	10.020342	10.524270
25	9.476133	9.979618	9.496515	10.503485	10.020382	10.523867
26	9.476536	9.979578	9.496957	10.503043	10.020421	10.523464
27	9.476938	9.979539	9.497399	10.502601	10.020461	10.523062
28	9.477340	9.979499	9.497841	10.502159	10.020501	10.522660
29	9.477741	9.979459	9.498282	10.501718	10.020541	10.522259
30	9.478142	9.979419	9.498722	10.501278	10.020580	10.521858
	Sine.		Tang.		Secant.	Min.

72 Degrees.

Tangents and Secants.

461

17 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.478142	9.979419	9.498722	10.501278
31	9.478542	9.979380	9.499163	10.500837
32	9.478942	9.979340	9.499603	10.500397
33	9.479342	9.979300	9.500042	10.499958
34	9.479741	9.979260	9.500481	10.499519
35	9.480140	9.979220	9.500920	10.499080
36	9.480538	9.979180	9.501359	10.498641
37	9.480937	9.979140	9.501797	10.498203
38	9.481334	9.979100	9.502235	10.497765
39	9.481731	9.979059	9.502672	10.497328
40	9.482128	9.979019	9.503109	10.496891
41	9.482525	9.978979	9.503546	10.496454
42	9.482921	9.978939	9.503982	10.496018
43	9.483316	9.978898	9.504418	10.495582
44	9.483712	9.978858	9.504854	10.495146
45	9.484107	9.978817	9.505289	10.494711
46	9.484501	9.978777	9.505724	10.494276
47	9.484895	9.978736	9.506159	10.493841
48	9.485289	9.978696	9.506595	10.493407
49	9.485682	9.978655	9.507037	10.492973
50	9.486075	9.978615	9.507460	10.492540
51	9.486467	9.978574	9.507893	10.492107
52	9.486859	9.978533	9.508326	10.491674
53	9.487251	9.978493	9.508759	10.491241
54	9.487643	9.978452	9.509191	10.490809
55	9.488033	9.978411	9.509622	10.490378
56	9.488424	9.978370	9.510054	10.489946
57	9.488814	9.978329	9.510485	10.489515
58	9.489204	9.978288	9.510916	10.489084
59	9.489593	9.978247	9.511346	10.488650
60	9.489982	9.978206	9.511776	10.488224
	Sine.	Tang.	Secant.	Min.

72 Degrees.

18 Degrees.

Min.	Sine.	Tang.	Secant.	Min.			
0	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	60
1	9.490371	9.978165	9.512206	10.487794	10.021835	10.509629	59
2	9.490759	9.978124	9.512635	10.487365	10.021876	10.509241	58
3	9.491147	9.978083	9.513064	10.486936	10.021917	10.508853	57
4	9.491534	9.978042	9.513493	10.486507	10.021958	10.508465	56
5	9.491922	9.978001	9.513921	10.486076	10.021999	10.508078	55
6	9.492308	9.977959	9.514349	10.485651	10.022041	10.507693	54
7	9.492695	9.977918	9.514777	10.485223	10.022082	10.507305	53
8	9.493081	9.977877	9.515204	10.484796	10.022123	10.506919	52
9	9.493466	9.977835	9.515631	10.484369	10.022165	10.506534	51
10	9.493851	9.977794	9.516057	10.483942	10.022206	10.506149	50
11	9.494236	9.977752	9.516484	10.483516	10.022248	10.505764	49
12	9.494620	9.977711	9.516910	10.483090	10.022289	10.505379	48
13	9.495005	9.977669	9.517335	10.482665	10.022331	10.504995	47
14	9.495388	9.977628	9.517751	10.482239	10.022372	10.504612	46
15	9.495772	9.977580	9.518185	10.481814	10.022414	10.504228	45
16	9.496154	9.977544	9.518610	10.481390	10.022456	10.503845	44
17	9.496537	9.977503	9.519034	10.480966	10.022497	10.503463	43
18	9.496919	9.977421	9.519458	10.480542	10.022539	10.503081	42
19	9.497301	9.977419	9.519882	10.480118	10.022581	10.502699	41
20	9.497682	9.977377	9.520305	10.479695	10.022623	10.502318	40
21	9.498063	9.977335	9.520728	10.479272	10.022665	10.501936	39
22	9.498444	9.977293	9.521151	10.478849	10.022707	10.501556	38
23	9.498824	9.977251	9.521573	10.478427	10.022748	10.501175	37
24	9.499204	9.977209	9.521995	10.478005	10.022790	10.500795	36
25	9.499584	9.977167	9.522417	10.477583	10.022833	10.500416	35
26	9.499963	9.977125	9.522838	10.477162	10.022875	10.500037	34
27	9.500342	9.977083	9.523259	10.476741	10.022917	10.499658	33
28	9.500721	9.977041	9.523679	10.476320	10.022959	10.499279	32
29	9.501099	9.976999	9.524100	10.475900	10.023001	10.498901	31
30	9.501476	9.976957	9.524520	10.475480	10.023045	10.498524	30
	Sine.	Tang.	Secant.	Min.			

71 Degrees.

Tangents and Secants.

(463)

18 Degree s.

Min.	Sine.	Tang.	Secant.	
30	9.501476	9.976957	9.524520	10.475480
31	9.501854	9.976914	9.524939	10.475060
32	9.502231	9.976872	9.525359	10.474641
33	9.502607	9.976830	9.525778	10.474222
34	9.502984	9.976787	9.526197	10.473803
35	9.503360	9.976745	9.526615	10.473385
36	9.503735	9.976702	9.527033	10.472967
37	9.504110	9.976660	9.527451	10.472549
38	9.504485	9.976617	9.527868	10.472132
39	9.504860	9.976574	9.528285	10.471715
40	9.505234	9.976532	9.528702	10.471298
41	9.505608	9.976489	9.529119	10.470881
42	9.505981	9.976446	9.529535	10.470465
43	9.506354	9.976404	9.529950	10.470049
44	9.506727	9.976361	9.530366	10.469634
45	9.507099	9.976318	9.530781	10.469219
46	9.507471	9.976275	9.531196	10.468804
47	9.507842	9.976232	9.531611	10.468389
48	9.508214	9.976189	9.532025	10.467975
49	9.508585	9.976146	9.532439	10.467561
50	9.508956	9.976103	9.532853	10.467147
51	9.509326	9.976060	9.533266	10.466734
52	9.509696	9.976017	9.533679	10.466321
53	9.510065	9.975974	9.534092	10.465908
54	9.510434	9.975930	9.534504	10.465496
55	9.510803	9.975887	9.534916	10.465084
56	9.511172	9.975844	9.535328	10.464672
57	9.511540	9.975800	9.535739	10.464261
58	9.511907	9.975757	9.536150	10.463849
59	9.512275	9.975713	9.536561	10.463439
60	9.512642	9.975670	9.536972	10.463028
	Sine.	Tang.	Secant.	Min.

71 Degrees.

19 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358
1	9.513009	9.975626	9.537382	10.462618	10.024373	10.486991
2	9.513375	9.975583	9.537792	10.462208	10.024417	10.486625
3	9.513741	9.975539	9.538202	10.461798	10.024461	10.486259
4	9.514107	9.975496	9.538611	10.461389	10.024504	10.485893
5	9.514472	9.975452	9.539020	10.460980	10.024548	10.485528
6	9.514837	9.975408	9.539429	10.460571	10.024592	10.485163
7	9.515202	9.975365	9.539837	10.460163	10.024635	10.484798
8	9.515566	9.975321	9.540245	10.459755	10.024679	10.484434
9	9.515930	9.975277	9.540653	10.459347	10.024723	10.484070
10	9.516294	9.975233	9.541061	10.458939	10.024767	10.483706
11	9.516657	9.975189	9.541468	10.458532	10.024811	10.483343
12	9.517020	9.975145	9.541875	10.458125	10.024855	10.482980
13	9.517382	9.975101	9.542281	10.457719	10.024899	10.482618
14	9.517745	9.975097	9.542688	10.457312	10.024943	10.482255
15	9.518107	9.975013	9.543094	10.456906	10.024987	10.481893
16	9.518468	9.974969	9.543499	10.456501	10.025031	10.481532
17	9.518829	9.974925	9.543905	10.456095	10.025075	10.481170
18	9.519190	9.974880	9.544310	10.455690	10.025120	10.480810
19	9.519551	9.974836	9.544715	10.455285	10.025164	10.480449
20	9.519911	9.974792	9.545119	10.454881	10.025208	10.480089
21	9.520271	9.974747	9.545524	10.454476	10.025252	10.479729
22	9.520631	9.974703	9.545928	10.454072	10.025297	10.479369
23	9.520990	9.974659	9.546331	10.453669	10.025341	10.479010
24	9.521349	9.974614	9.546735	10.453265	10.025386	10.478651
25	9.521707	9.974570	9.547138	10.452862	10.025430	10.478293
26	9.522066	9.974525	9.547540	10.452459	10.025475	10.477934
27	9.522423	9.974481	9.547940	10.452057	10.025519	10.477576
28	9.522781	9.974436	9.548347	10.451655	10.025564	10.477219
29	9.523138	9.974391	9.548748	10.451253	10.025609	10.476862
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505
		Sine.		Tang.		Secant.

70 Degrees.

Tangents and Secants.

465

19 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.523495	9.974347	9.549149	10.450851
31	9.523852	9.974302	9.549550	10.450450
32	9.524208	9.974257	9.549951	10.450049
33	9.524564	9.974212	9.550352	10.449648
34	9.524920	9.974167	9.550752	10.449248
35	9.525275	9.974122	9.551152	10.448847
36	9.525630	9.974077	9.551552	10.448448
37	9.525984	9.974032	9.551952	10.448048
38	9.526339	9.973987	9.552352	10.447649
39	9.526693	9.973942	9.552750	10.447250
40	9.527046	9.973897	9.553149	10.446851
41	9.527400	9.973852	9.553548	10.446452
42	9.527753	9.973807	9.553946	10.446054
43	9.528105	9.973761	9.554344	10.445656
44	9.528458	9.973716	9.554741	10.445258
45	9.528810	9.973671	9.555139	10.444861
46	9.529161	9.973625	9.555536	10.444464
47	9.529514	9.973580	9.555933	10.444067
48	9.529864	9.973535	9.556329	10.443671
49	9.530215	9.973489	9.556725	10.443274
50	9.530565	9.973443	9.557121	10.442879
51	9.530915	9.973398	9.557517	10.442483
52	9.531265	9.973352	9.557912	10.442087
53	9.531614	9.973307	9.558308	10.441692
54	9.531963	9.973261	9.558702	10.441297
55	9.532312	9.973215	9.559097	10.440903
56	9.532661	9.973169	9.559491	10.440509
57	9.533009	9.973124	9.559885	10.440115
58	9.533357	9.973078	9.560279	10.439721
59	9.533704	9.973032	9.560673	10.439327
60	9.534052	9.972986	9.561066	10.438934
	Sine.	Tang.	Secant.	Min.

70 Degrees.

26 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.534050	9.972985	9.561066	10.438934	10.027014	10.465948
1	9.534329	9.972940	9.561459	10.438541	10.027060	10.465601
2	9.534745	9.972894	9.561851	10.438148	10.027106	10.465255
3	9.535091	9.972848	9.562244	10.437756	10.027152	10.464908
4	9.535437	9.972802	9.562636	10.437364	10.027198	10.464562
5	9.535783	9.972755	9.563028	10.436972	10.027245	10.464217
6	9.536129	9.972709	9.563419	10.436581	10.027291	10.463871
7	9.536474	9.972663	9.563811	10.436189	10.027337	10.463526
8	9.536818	9.972617	9.564202	10.435798	10.027383	10.463182
9	9.537163	9.972570	9.564592	10.435407	10.027430	10.462837
10	9.537567	9.972574	9.564983	10.435017	10.027476	10.462493
11	9.537851	9.972477	9.565373	10.434627	10.027522	10.462149
12	9.538194	9.972431	9.565763	10.434237	10.027569	10.461806
13	9.538537	9.972384	9.566153	10.433847	10.027615	10.461462
14	9.538880	9.972338	9.566542	10.433458	10.027662	10.461120
15	9.539223	9.972291	9.566932	10.433068	10.027709	10.460777
16	9.539665	9.972245	9.567320	10.432679	10.027755	10.460435
17	9.539907	9.972198	9.567709	10.432291	10.027802	10.460093
18	9.540249	9.972151	9.568097	10.431902	10.027849	10.459751
19	9.540590	9.972105	9.568480	10.431514	10.027895	10.459410
20	9.540931	9.972058	9.568873	10.431126	10.027942	10.459069
21	9.541272	9.972011	9.569261	10.430739	10.027989	10.458728
22	9.541613	9.971964	9.569648	10.430352	10.028036	10.458387
23	9.541953	9.971917	9.570035	10.429964	10.028083	10.458047
24	9.542293	9.971870	9.570422	10.429578	10.028130	10.457707
25	9.542532	9.971823	9.570809	10.429191	10.028177	10.457368
26	9.542971	9.971770	9.571195	10.428805	10.028224	10.457029
27	9.543310	9.971729	9.571581	10.428419	10.028271	10.456690
28	9.543649	9.971683	9.571967	10.428033	10.028318	10.456351
29	9.543987	9.971635	9.572352	10.427648	10.028365	10.456013
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675
	Sine.		Tang.		Secant.	Min.

69 Degrees.

Tangents and Secants.

46 7

20 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.544325	9.572738	10.427262	30
31	9.544663	9.573123	10.426877	29
32	9.545000	9.573507	10.426493	28
33	9.545338	9.573892	10.426108	27
34	9.545674	9.574276	10.425724	26
35	9.546011	9.574660	10.425340	25
36	9.546347	9.575044	10.424956	24
37	9.546683	9.575427	10.424573	23
38	9.547019	9.575810	10.424190	22
39	9.547354	9.576193	10.423807	21
40	9.547689	9.576576	10.423424	20
41	9.548024	9.576958	10.423041	19
42	9.548358	9.577341	10.422659	18
43	9.548693	9.577723	10.422277	17
44	9.549027	9.578104	10.421896	16
45	9.549360	9.578486	10.421514	15
46	9.549693	9.578867	10.421133	14
47	9.550026	9.579248	10.420752	13
48	9.550359	9.579629	10.420371	12
49	9.550692	9.580009	10.419991	11
50	9.551024	9.580389	10.419611	10
51	9.551356	9.580769	10.419231	9
52	9.551687	9.581149	10.418851	8
53	9.552018	9.581528	10.418472	7
54	9.552349	9.581907	10.418093	6
55	9.552680	9.582286	10.417714	5
56	9.553010	9.582665	10.417335	4
57	9.553341	9.583043	10.416956	3
58	9.553670	9.583422	10.416576	2
59	9.554000	9.583800	10.416200	1
60	9.554329	9.584177	10.415823	0
	Sine.	Tang.	Secant.	

69 Degrees.

21 Degrees.

Min.	Sine.		Tang		Secant.		Min.
0	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	60
1	9.554658	9.970103	9.584555	10.415445	10.029897	10.445342	59
2	9.554987	9.970055	9.584932	10.415068	10.029945	10.445013	58
3	9.555315	9.970006	9.585309	10.414691	10.029994	10.444685	57
4	9.555645	9.969957	9.585686	10.414314	10.030043	10.444357	56
5	9.555971	9.969909	9.586062	10.413938	10.030091	10.444029	55
6	9.556299	9.969860	9.586439	10.413561	10.030140	10.443701	54
7	9.556626	9.969811	9.586815	10.413185	10.030189	10.443374	53
8	9.556953	9.969762	9.587190	10.412810	10.030238	10.443047	52
9	9.557280	9.969714	9.587566	10.412434	10.030286	10.442720	51
10	9.557606	9.969665	9.587941	10.412059	10.030335	10.442394	50
11	9.557932	9.969616	9.588316	10.411684	10.030384	10.442068	49
12	9.558258	9.969567	9.588691	10.411309	10.030433	10.441742	48
13	9.558583	9.969518	9.589066	10.410930	10.030482	10.441416	47
14	9.558909	9.969469	9.589440	10.410560	10.030531	10.441092	46
15	9.559234	9.969420	9.589814	10.410185	10.030580	10.440761	45
16	9.559558	9.969370	9.590188	10.409812	10.030630	10.440441	44
17	9.559883	9.969321	9.590562	10.409438	10.030679	10.440117	43
18	9.560207	9.969272	9.590935	10.409065	10.030728	10.439793	42
19	9.560531	9.969223	9.591308	10.408692	10.030777	10.439469	41
20	9.560855	9.969173	9.591681	10.408319	10.030827	10.439145	40
21	9.561178	9.969124	9.592054	10.407946	10.030876	10.438822	39
22	9.561501	9.969075	9.592426	10.407574	10.030925	10.438499	38
23	9.561824	9.969025	9.592798	10.407201	10.030975	10.438176	37
24	9.562146	9.968976	9.593170	10.406829	10.031024	10.437854	36
25	9.562468	9.968926	9.593542	10.406458	10.031074	10.437531	35
26	9.562790	9.968877	9.593914	10.406086	10.031123	10.437210	34
27	9.563112	9.968827	9.594285	10.405715	10.031173	10.436888	33
28	9.563433	9.968777	9.594656	10.405344	10.031223	10.436566	32
29	9.563755	9.968728	9.595027	10.404973	10.031272	10.436245	31
30	9.564075	9.968678	9.595397	10.404602	10.031322	10.435925	30
		Sine.		Tang.		Secant.	

68 Degrees.

Tangents and Secants.

469

21 Degrees.

Min.	Sine.	Tang.	Secant	Min.
30	9.564075	9.968678	10.404601	30
31	9.564396	9.968628	10.404232	29
32	9.564716	9.968578	10.403862	28
33	9.565036	9.968528	10.403492	27
34	9.565356	9.968478	10.403122	26
35	9.565676	9.968429	10.402753	25
36	9.565995	9.968379	10.402384	24
37	9.566314	9.968328	10.402015	23
38	9.566632	9.968278	10.401646	22
39	9.566951	9.968228	10.401277	21
40	9.567259	9.968178	10.400909	20
41	9.567587	9.968128	10.400541	19
42	9.567904	9.968078	10.400172	18
43	9.568222	9.968027	10.399806	17
44	9.568539	9.967977	10.399438	16
45	9.568855	9.967927	10.399071	15
46	9.569172	9.967876	10.398704	14
47	9.569488	9.967826	10.398337	13
48	9.569804	9.967775	10.397971	12
49	9.570126	9.967725	10.397605	11
50	9.570435	9.967674	10.397239	10
51	9.570751	9.967623	10.396872	9
52	9.571066	9.967572	10.396507	8
53	9.571380	9.967522	10.396142	7
54	9.571695	9.967471	10.395777	6
55	9.572009	9.967420	10.395412	5
56	9.572323	9.967370	10.395047	4
57	9.572635	9.967319	10.394682	3
58	9.572949	9.967268	10.394318	2
59	9.573263	9.967217	10.393954	1
60	9.573575	9.967166	10.393590	0
	Sine.	Tang.	Secant.	Min.

68 Degrees.

113

22 Degrees.

Min.	Sine.	Tang.	Secant.
0	9.573575	9.667166	9.605410
1	9.573888	9.667115	9.606773
2	9.574200	9.667064	9.607137
3	9.574512	9.667012	9.607500
4	9.574824	9.666961	9.607863
5	9.575136	9.666910	9.608225
6	9.575447	9.666859	9.608588
7	9.575758	9.666807	9.608950
8	9.576068	9.666756	9.609312
9	9.576379	9.666705	9.609674
10	9.576689	9.666653	9.610036
11	9.576999	9.666602	9.610397
12	9.577309	9.666550	9.610759
13	9.577618	9.666499	9.611120
14	9.577927	9.666447	9.611480
15	9.578236	9.666395	9.611841
16	9.578545	9.666344	9.612201
17	9.578853	9.666292	9.612561
18	9.579162	9.666240	9.612921
19	9.579469	9.666188	9.613281
20	9.579777	9.666136	9.613641
21	9.580084	9.666085	9.614000
22	9.580392	9.666032	9.614359
23	9.580699	9.665981	9.614718
24	9.581005	9.665928	9.615077
25	9.581312	9.665876	9.615435
26	9.581618	9.665824	9.615793
27	9.581924	9.665772	9.616151
28	9.582229	9.665720	9.616509
29	9.582534	9.665668	9.616867
30	9.582840	9.665615	9.617224
	Sine.	Tang.	Secant.

67 Degrees.

Tangents and Secants.

47

22 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.582840	9.656155	10.382776	10
31	9.583144	9.655563	10.382418	29
32	9.583449	9.655111	10.382061	28
33	9.583753	9.654588	10.381705	27
34	9.584058	9.654066	10.381347	26
35	9.584361	9.653533	10.380992	25
36	9.584665	9.653011	10.380635	24
37	9.584968	9.652488	10.380279	23
38	9.585272	9.651955	10.379924	22
39	9.585574	9.651432	10.379568	21
40	9.585877	9.650900	10.379213	20
41	9.586179	9.650377	10.378858	19
42	9.586482	9.649844	10.378503	18
43	9.586783	9.649311	10.378145	17
44	9.587085	9.648788	10.377793	16
45	9.587386	9.648266	10.377439	15
46	9.587688	9.647733	10.377085	14
47	9.587988	9.647199	10.376731	13
48	9.588289	9.646666	10.376377	12
49	9.588590	9.646132	10.376024	11
50	9.588890	9.645500	10.375670	10
51	9.589190	9.645077	10.375317	9
52	9.589489	9.644554	10.374964	8
53	9.589789	9.644009	10.374612	7
54	9.590088	9.643477	10.374299	6
55	9.590387	9.642944	10.373907	5
56	9.590686	9.642409	10.373555	4
57	9.590984	9.641877	10.373203	3
58	9.591282	9.641333	10.372851	2
59	9.591580	9.640809	10.372499	1
60	9.591878	9.640266	10.372148	0
	Sine.	Tang.	Secant.	Min.

67 Degrees.

23 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
0	9.591878	9.627852	10.372148	10.408122
1	9.592175	9.628203	10.371797	10.407824
2	9.592473	9.628554	10.371446	10.407527
3	9.592770	9.628905	10.371095	10.407230
4	9.593067	9.629255	10.370745	10.406933
5	9.593363	9.629606	10.370394	10.406637
6	9.593659	9.629956	10.370044	10.406341
7	9.593955	9.630306	10.369694	10.406044
8	9.594251	9.630656	10.369344	10.405749
9	9.594547	9.631005	10.368995	10.405453
10	9.594842	9.631354	10.368645	10.405158
11	9.595137	9.631704	10.368296	10.404863
12	9.595432	9.632053	10.367947	10.404568
13	9.595727	9.632403	10.367598	10.404273
14	9.596021	9.632750	10.367250	10.403979
15	9.596315	9.633098	10.366901	10.403685
16	9.596609	9.633447	10.366553	10.403391
17	9.596903	9.633795	10.366205	10.403097
18	9.597196	9.634143	10.365857	10.402803
19	9.597490	9.634490	10.365510	10.402510
20	9.597783	9.634838	10.365162	10.402217
21	9.598075	9.635185	10.364815	10.401925
22	9.598368	9.635532	10.364468	10.401632
23	9.598660	9.635879	10.364121	10.401340
24	9.598952	9.636226	10.363774	10.401048
25	9.599244	9.636572	10.363428	10.400756
26	9.599536	9.636918	10.363081	10.400464
27	9.599827	9.637265	10.362735	10.400173
28	9.600118	9.637611	10.362389	10.399881
29	9.600409	9.637956	10.362044	10.399591
30	9.600700	9.638302	10.361698	10.399300
	Sine.	Tang.	Secant.	Min.

66 Degrees.

Tangents and Secants.

473

23 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.600700	9.623398	10.361698	30
31	9.600990	9.623443	10.361353	29
32	9.601280	9.622888	10.361007	28
33	9.601570	9.622331	10.360662	27
34	9.601860	9.621788	10.360318	26
35	9.602149	9.621233	10.359973	25
36	9.602439	9.620677	10.359629	24
37	9.602728	9.620122	10.359284	23
38	9.603017	9.619567	10.358940	22
39	9.603305	9.619012	10.358596	21
40	9.603594	9.618456	10.358253	20
41	9.603882	9.617901	10.357909	19
42	9.604170	9.617345	10.357566	18
43	9.604457	9.616789	10.357223	17
44	9.604745	9.616234	10.356880	16
45	9.605032	9.615679	10.356537	15
46	9.605319	9.615123	10.356194	14
47	9.605606	9.614568	10.355852	13
48	9.605892	9.614012	10.355510	12
49	9.606179	9.613456	10.355168	11
50	9.606465	9.612900	10.354826	10
51	9.606751	9.612345	10.354484	9
52	9.607036	9.611789	10.354142	8
53	9.607322	9.611233	10.353801	7
54	9.607607	9.610677	10.353460	6
55	9.607892	9.610121	10.353119	5
56	9.608176	9.609565	10.352778	4
57	9.608461	9.609009	10.352438	3
58	9.608745	9.608453	10.352097	2
59	9.609029	9.607896	10.351757	1
60	9.609313	9.607340	10.351417	0
	Sine.	Tang.	Secant.	Min.

66 Degrees.

24 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687
1	9.609597	9.960674	9.648923	10.351077	10.039326	10.390403
2	9.609880	9.960618	9.649263	10.350737	10.039382	10.390120
3	9.610163	9.960561	9.649602	10.350398	10.039439	10.389836
4	9.610446	9.960505	9.649942	10.350058	10.039495	10.389553
5	9.610729	9.960448	9.650281	10.349719	10.039552	10.389271
6	9.611012	9.960392	9.650620	10.349380	10.039608	10.388988
7	9.611294	9.960335	9.650959	10.349041	10.039665	10.388706
8	9.611576	9.960279	9.651297	10.348703	10.039721	10.388424
9	9.611858	9.960222	9.651636	10.348364	10.039778	10.388142
10	9.612140	9.960165	9.651974	10.348026	10.039834	10.387860
11	9.612421	9.960109	9.652312	10.347688	10.039891	10.387579
12	9.612702	9.960052	9.652650	10.347350	10.039948	10.387298
13	9.612983	9.959995	9.652988	10.347012	10.040005	10.387017
14	9.613264	9.959938	9.653326	10.346674	10.040062	10.386736
15	9.613545	9.959881	9.653663	10.346337	10.040118	10.386455
16	9.613825	9.959825	9.654000	10.346000	10.040175	10.386175
17	9.614105	9.959768	9.654337	10.345662	10.040232	10.385895
18	9.614385	9.959711	9.654674	10.345326	10.040289	10.385615
19	9.614665	9.959653	9.655011	10.344989	10.040346	10.385335
20	9.614944	9.959596	9.655348	10.344652	10.040404	10.385056
21	9.615223	9.959539	9.655684	10.344316	10.040461	10.384777
22	9.615502	9.959482	9.656020	10.343980	10.040518	10.384498
23	9.615781	9.959425	9.656356	10.343644	10.040575	10.384216
24	9.616060	9.959367	9.656692	10.343308	10.040632	10.383940
25	9.616338	9.959310	9.657028	10.342972	10.040690	10.383662
26	9.616616	9.959253	9.657364	10.342636	10.040747	10.383384
27	9.616894	9.959195	9.657699	10.342301	10.040805	10.383106
28	9.617172	9.959138	9.658034	10.341966	10.040862	10.382828
29	9.617450	9.959080	9.658369	10.341631	10.040919	10.382550
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273
	Sine.		Tang.		Secant.	Min.

65 Degrees.

Tangents and Secants.

475

24 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
31	9.618004	9.958965	9.659039	10.340961	10.041035	10.381996	29
32	9.618281	9.958908	9.659373	10.340627	10.041092	10.381719	28
33	9.618558	9.958850	9.659708	10.340292	10.041150	10.381442	27
34	9.618834	9.958792	9.660042	10.339958	10.041208	10.381166	26
35	9.619110	9.958734	9.660376	10.339624	10.041265	10.380890	25
36	9.619386	9.958677	9.660710	10.339290	10.041323	10.380614	24
37	9.619662	9.958619	9.661043	10.338957	10.041381	10.380338	23
38	9.619938	9.958561	9.661377	10.338623	10.041439	10.380062	22
39	9.620213	9.958503	9.661710	10.338290	10.041497	10.379787	21
40	9.620488	9.958445	9.662043	10.337957	10.041555	10.379512	20
41	9.620763	9.958387	9.662376	10.337623	10.041613	10.379237	19
42	9.621038	9.958329	9.662709	10.337291	10.041671	10.378962	18
43	9.621313	9.958271	9.663042	10.336958	10.041729	10.378687	17
44	9.621587	9.958212	9.663374	10.336625	10.041787	10.378413	16
45	9.621861	9.958154	9.663707	10.336293	10.041846	10.378139	15
46	9.622135	9.958095	9.664039	10.335961	10.041904	10.377865	14
47	9.622409	9.958038	9.664371	10.335629	10.041962	10.377591	13
48	9.622682	9.957979	9.664703	10.335297	10.042021	10.377318	12
49	9.622956	9.957921	9.665035	10.334965	10.042079	10.377044	11
50	9.623229	9.957863	9.665366	10.334634	10.042137	10.376771	10
51	9.623502	9.957804	9.665697	10.334302	10.042196	10.376498	9
52	9.623774	9.957746	9.666029	10.333971	10.042254	10.376226	8
53	9.624047	9.957687	9.666360	10.333640	10.042313	10.375953	7
54	9.624319	9.957628	9.666691	10.333309	10.042372	10.375681	6
55	9.624591	9.957570	9.667021	10.332979	10.042430	10.375409	5
56	9.624863	9.957511	9.667352	10.332648	10.042489	10.375137	4
57	9.625135	9.957452	9.667682	10.332318	10.042548	10.374865	3
58	9.625406	9.957393	9.668013	10.331987	10.042607	10.374594	2
59	9.625677	9.957335	9.668343	10.331657	10.042665	10.374323	1
60	9.625948	9.957276	9.668672	10.331327	10.042724	10.374052	0
	Sine.		Tang.		Secant.		

65 Degrees.

25 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.625948	9.957276	9.668672	10.331327	10.042724	10.374052
1	9.626219	9.957217	9.669002	10.330998	10.042783	10.373781
2	9.626490	9.957158	9.669332	10.330668	10.042842	10.373510
3	9.626760	9.957099	9.669661	10.330339	10.042901	10.373240
4	9.627030	9.957040	9.669991	10.330009	10.042960	10.372970
5	9.627300	9.956981	9.670320	10.329680	10.043019	10.372700
6	9.627570	9.956921	9.670649	10.329351	10.043078	10.372430
7	9.627840	9.956862	9.670977	10.329023	10.043138	10.372150
8	9.628109	9.956803	9.671306	10.328694	10.043197	10.371891
9	9.628378	9.956744	9.671624	10.328365	10.043256	10.371622
10	9.628647	9.956684	9.671963	10.328037	10.043316	10.371353
11	9.628916	9.956625	9.672291	10.327709	10.043375	10.371084
12	9.629184	9.956566	9.672619	10.327381	10.043434	10.370815
13	9.629453	9.956506	9.672947	10.327053	10.043494	10.370547
14	9.629721	9.956447	9.673274	10.326725	10.043553	10.370276
15	9.629989	9.956387	9.673602	10.326398	10.043613	10.370011
16	9.630257	9.956327	9.673929	10.326071	10.043673	10.369743
17	9.630524	9.956268	9.674257	10.325743	10.043732	10.369476
18	9.630792	9.956208	9.674584	10.325416	10.043792	10.369208
19	9.631059	9.956148	9.674910	10.325089	10.043852	10.368941
20	9.631326	9.956089	9.675237	10.324763	10.043911	10.368674
21	9.631593	9.956029	9.675564	10.324436	10.043971	10.368407
22	9.631859	9.955969	9.675890	10.324110	10.044031	10.368141
23	9.632125	9.955909	9.676216	10.323783	10.044091	10.367874
24	9.632392	9.955849	9.676543	10.323457	10.044151	10.367608
25	9.632658	9.955789	9.676869	10.323131	10.044211	10.367342
26	9.632923	9.955729	9.677194	10.322806	10.044271	10.367077
27	9.633189	9.955669	9.677520	10.322480	10.044331	10.366811
28	9.633454	9.955609	9.677846	10.322154	10.044391	10.366546
29	9.633719	9.955548	9.678171	10.321829	10.044451	10.366281
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016
	Sine.		Tang.		Secant.	Min.

64 Degrees.

Tangents and Secants.

477

25 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.633984	9.955488	9.678496	10.321504
31	9.634249	9.955428	9.678821	10.321179
32	9.634514	9.955368	9.679145	10.320854
33	9.634778	9.955307	9.672471	10.320529
34	9.635042	9.955247	9.679795	10.320205
35	9.635306	9.955186	9.680120	10.319880
36	9.635570	9.955126	9.680444	10.319556
37	9.635833	9.955065	9.680768	10.319232
38	9.636097	9.955005	9.681092	10.318908
39	9.636360	9.954944	9.681416	10.318584
40	9.636623	9.954883	9.681740	10.318260
41	9.636886	9.954823	9.682063	10.317937
42	9.637148	9.954762	9.682386	10.317613
43	9.637411	9.954701	9.682710	10.317290
44	9.637673	9.954640	9.683033	10.316967
45	9.637935	9.954579	9.683356	10.316644
46	9.638197	9.954518	9.683678	10.316321
47	9.638458	9.954457	9.684001	10.315999
48	9.638720	9.954396	9.684324	10.315676
49	9.638981	9.954335	9.684646	10.315354
50	9.639242	9.954274	9.684968	10.315032
51	9.639503	9.954213	9.685290	10.314710
52	9.639764	9.954152	9.685612	10.314388
53	9.640024	9.954090	9.685934	10.314056
54	9.640284	9.954029	9.686255	10.313745
55	9.640544	9.953968	9.686577	10.313423
56	9.640804	9.953906	9.686898	10.313102
57	9.641064	9.953845	9.687219	10.312781
58	9.641323	9.953783	9.687540	10.312460
59	9.641583	9.953722	9.687861	10.312139
60	9.641842	9.953660	9.688182	10.311818
	Sine.	Tang.	Secant.	Min.

64 Degrees.

26 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158
1	9.642101	9.953598	9.688502	10.311498	10.046401	10.357899
2	9.642360	9.953537	9.688823	10.311177	10.046463	10.357640
3	9.642618	9.953475	9.689143	10.310857	10.046525	10.357382
4	9.642876	9.953413	9.689463	10.310537	10.046587	10.357123
5	9.643135	9.953351	9.689783	10.310217	10.046648	10.356865
6	9.643393	9.953290	9.690103	10.309897	10.046710	10.356607
7	9.643650	9.953228	9.690423	10.309577	10.046772	10.356350
8	9.643908	9.953166	9.690742	10.309258	10.046834	10.356092
9	9.644165	9.953104	9.691091	10.308938	10.046896	10.355835
10	9.644423	9.953042	9.691381	10.308619	10.046958	10.355577
11	9.644680	9.952980	9.691700	10.308300	10.047020	10.355320
12	9.644936	9.952917	9.692019	10.307981	10.047082	10.355063
13	9.645193	9.952855	9.692338	10.307662	10.047145	10.354807
14	9.645450	9.952793	9.692656	10.307343	10.047207	10.354550
15	9.645706	9.952731	9.692975	10.307025	10.047269	10.354294
16	9.645962	9.952668	9.693293	10.306707	10.047331	10.354038
17	9.646218	9.952606	9.693612	10.306388	10.047394	10.353782
18	9.646473	9.952544	9.693930	10.306070	10.047456	10.353526
19	9.646729	9.952481	9.694248	10.305752	10.047519	10.353271
20	9.646984	9.952419	9.694566	10.305434	10.047581	10.353016
21	9.647239	9.952356	9.694883	10.305117	10.047644	10.352760
22	9.647494	9.952294	9.695201	10.304799	10.047706	10.352505
23	9.647749	9.952231	9.695518	10.304481	10.047769	10.352251
24	9.648004	9.952168	9.695835	10.304164	10.047832	10.351996
25	9.648258	9.952105	9.696153	10.303847	10.047894	10.351742
26	9.648512	9.952043	9.696470	10.303530	10.047957	10.351488
27	9.648766	9.951980	9.696786	10.303213	10.048020	10.351233
28	9.649020	9.951917	9.697103	10.302897	10.048083	10.350980
29	9.649274	9.951854	9.697420	10.302580	10.048146	10.350726
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473
	Sine.		Tang.		Secant.	Min.

63 Degrees.

Tangents and Secants.

479

26 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
31	9.649781	9.951728	9.698053	10.301947	10.048272	10.350219	29
32	9.650034	9.951665	9.698369	10.301631	10.048335	10.349966	28
33	9.650287	9.951602	9.698685	10.301315	10.048398	10.349713	27
34	9.650539	9.951539	9.699001	10.300999	10.048461	10.349460	26
35	9.650702	9.951476	9.699316	10.300684	10.048524	10.349208	25
36	9.651044	9.951412	9.699632	10.300368	10.048588	10.348956	24
37	9.651297	9.951349	9.699947	10.300053	10.048651	10.348703	23
38	9.651549	9.951286	9.700263	10.299737	10.048714	10.348451	22
39	9.651800	9.951222	9.700578	10.299422	10.048778	10.348200	21
40	9.652052	9.951159	9.700893	10.299107	10.048841	10.347948	20
41	9.652303	9.951096	9.701208	10.298792	10.048904	10.347696	19
42	9.652555	9.951032	9.701523	10.298477	10.048968	10.347445	18
43	9.652806	9.950968	9.701837	10.298163	10.049031	10.347194	17
44	9.653057	9.950905	9.702152	10.297848	10.049095	10.346943	16
45	9.653307	9.950841	9.702466	10.297534	10.049159	10.346692	15
46	9.653558	9.950777	9.702780	10.297219	10.049222	10.346442	14
47	9.653808	9.950714	9.703095	10.296905	10.049286	10.346192	13
48	9.654059	9.950650	9.703409	10.296591	10.049350	10.345941	12
49	9.654309	9.950586	9.703722	10.296277	10.049414	10.345691	11
50	9.654558	9.950522	9.704036	10.295964	10.049478	10.345442	10
51	9.654808	9.950458	9.704350	10.295650	10.049542	10.345192	9
52	9.655057	9.950394	9.704663	10.295337	10.049606	10.344942	8
53	9.655307	9.950330	9.704976	10.295023	10.049670	10.344693	7
54	9.655556	9.950266	9.705290	10.294710	10.049734	10.344444	6
55	9.655805	9.950202	9.705603	10.294397	10.049798	10.344195	5
56	9.656054	9.950138	9.705916	10.294084	10.049862	10.343946	4
57	9.656302	9.950074	9.706228	10.293772	10.049926	10.343698	3
58	9.656550	9.950009	9.706541	10.293459	10.049990	10.343449	2
59	9.656799	9.949945	9.706853	10.293146	10.050055	10.343201	1
60	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	0
	Sine.		Tang.		Secant.		Min.

63 Degrees.

27 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.657047	9.949881	9.707160	10.292834	10.050119	10.342953
1	9.657295	9.949816	9.707478	10.292522	10.050183	10.342705
2	9.657542	9.949752	9.707790	10.292210	10.050248	10.342458
3	9.657790	9.949688	9.708102	10.291898	10.050312	10.342210
4	9.658037	9.949623	9.708414	10.291586	10.050377	10.341963
5	9.658284	9.949558	9.708726	10.291274	10.050441	10.341716
6	9.658531	9.949494	9.709037	10.290963	10.050506	10.341469
7	9.658778	9.949429	9.709349	10.290651	10.050571	10.341222
8	9.659025	9.949364	9.709660	10.290340	10.050635	10.340975
9	9.659271	9.949300	9.709971	10.290029	10.050700	10.340729
10	9.659517	9.949235	9.710282	10.289718	10.050765	10.340483
11	9.659763	9.949170	9.710593	10.289407	10.050830	10.340237
12	9.660009	9.949105	9.710904	10.289096	10.050895	10.339991
13	9.660255	9.949040	9.711215	10.288785	10.050960	10.339745
14	9.660500	9.948975	9.711525	10.288475	10.051025	10.339499
15	9.660746	9.948910	9.711836	10.288164	10.051090	10.339254
16	9.660991	9.948845	9.712146	10.287854	10.051155	10.339009
17	9.661236	9.948780	9.712456	10.287544	10.051220	10.338764
18	9.661481	9.948715	9.712766	10.287234	10.051285	10.338519
19	9.661726	9.948649	9.713076	10.286924	10.051350	10.338274
20	9.661970	9.948584	9.713386	10.286614	10.051416	10.338030
21	9.662214	9.948519	9.713696	10.286304	10.051481	10.337785
22	9.662459	9.948453	9.714005	10.285995	10.051546	10.337541
23	9.662703	9.948388	9.714314	10.285685	10.051612	10.337297
24	9.662946	9.948323	9.714624	10.285376	10.051677	10.337054
25	9.663190	9.948257	9.714933	10.285067	10.051743	10.336810
26	9.663433	9.948192	9.715242	10.284758	10.051808	10.336566
27	9.663677	9.948126	9.715551	10.284449	10.051874	10.336323
28	9.663920	9.948060	9.715859	10.284140	10.051940	10.336080
29	9.664163	9.947995	9.716168	10.283832	10.052005	10.335837
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594
	Sine.		Tang.		Secant.	Min.

62 Degrees.

Tangents and Secants.

481

27 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594
31	9.664648	9.947863	9.716785	10.283215	10.052137	10.335552
32	9.664891	9.947797	9.717093	10.282907	10.052203	10.335509
33	9.665133	9.947731	9.717401	10.282599	10.052269	10.334867
34	9.665375	9.947665	9.717709	10.282291	10.052334	10.334625
35	9.665617	9.947599	9.718017	10.281983	10.052400	10.334383
36	9.665859	9.947533	9.718325	10.281675	10.052466	10.334141
37	9.666100	9.947467	9.718633	10.281367	10.052533	10.333900
38	9.666341	9.947401	9.718940	10.281060	10.052599	10.333658
39	9.666583	9.947335	9.719248	10.280752	10.052665	10.333417
40	9.666824	9.947269	9.719555	10.280445	10.052731	10.333176
41	9.667065	9.947203	9.719862	10.280138	10.052797	10.332935
42	9.667305	9.947136	9.720169	10.279831	10.052864	10.332695
43	9.667546	9.947070	9.720476	10.279524	10.052930	10.332454
44	9.667786	9.947004	9.720783	10.279217	10.052996	10.332214
45	9.668026	9.946937	9.721089	10.278911	10.053063	10.331973
46	9.668266	9.946871	9.721396	10.278604	10.053129	10.331733
47	9.668506	9.946804	9.721702	10.278298	10.053195	10.331494
48	9.668746	9.946738	9.722008	10.277991	10.053262	10.331254
49	9.668986	9.946671	9.722315	10.277685	10.053328	10.331014
50	9.669225	9.946604	9.722621	10.277379	10.053396	10.330775
51	9.669464	9.946538	9.722927	10.277073	10.053462	10.330536
52	9.669703	9.946471	9.723232	10.276768	10.053529	10.330297
53	9.669942	9.946404	9.723538	10.276462	10.053596	10.330058
54	9.670181	9.946337	9.723844	10.276156	10.053663	10.329819
55	9.670419	9.946270	9.724149	10.275851	10.053730	10.329581
56	9.670658	9.946203	9.724454	10.275546	10.053797	10.329342
57	9.670896	9.946136	9.724759	10.275240	10.053864	10.329104
58	9.671134	9.946069	9.725065	10.274935	10.053931	10.328866
59	9.671372	9.946002	9.725369	10.274630	10.053998	10.328628
60	9.671609	9.945930	9.725674	10.274326	10.054065	10.328391
	Sine.		Tang.		Secant.	Min.

62 Degrees.

K k

28 Degrees.

Min.	Sine.		Tang.		Secant.		
0	9.671009	9.945935	9.725674	10.274326	10.054065	10.328391	60
1	9.671847	9.945868	9.725979	10.274021	10.054132	10.328153	59
2	9.672084	9.945800	9.726284	10.273716	10.054199	10.327916	58
3	9.672321	9.945733	9.726588	10.273412	10.054267	10.327679	57
4	9.672558	9.945666	9.726892	10.273107	10.054334	10.327442	56
5	9.672795	9.945598	9.727197	10.272803	10.054401	10.327205	55
6	9.673032	9.945531	9.727501	10.272499	10.054469	10.326968	54
7	9.673268	9.945464	9.727805	10.272195	10.054536	10.326732	53
8	9.673505	9.945396	9.728109	10.271891	10.054604	10.326495	52
9	9.673741	9.945328	9.728412	10.271588	10.054671	10.326259	51
10	9.673977	9.945261	9.728716	10.271284	10.054739	10.326023	50
11	9.674213	9.945193	9.729020	10.270980	10.054807	10.325787	49
12	9.674448	9.945125	9.729323	10.270677	10.054874	10.325551	48
13	9.674684	9.945058	9.729626	10.270374	10.054942	10.325316	47
14	9.674919	9.944990	9.729929	10.270070	10.055010	10.325081	46
15	9.675155	9.944922	9.730232	10.269767	10.055078	10.324845	45
16	9.675390	9.944855	9.730534	10.269465	10.055146	10.324610	44
17	9.675624	9.944786	9.730838	10.269162	10.055214	10.324376	43
18	9.675859	9.944718	9.731141	10.268859	10.055282	10.324141	42
19	9.676094	9.944650	9.731444	10.268556	10.055350	10.323906	41
20	9.676328	9.944582	9.731746	10.268254	10.055418	10.323672	40
21	9.676562	9.944514	9.732048	10.267952	10.055486	10.323438	39
22	9.676796	9.944446	9.732351	10.267649	10.055554	10.323204	38
23	9.677030	9.944377	9.732653	10.267347	10.055622	10.322970	37
24	9.677264	9.944309	9.732955	10.267045	10.055691	10.322736	36
25	9.677497	9.944241	9.733257	10.266743	10.055759	10.322502	35
26	9.677731	9.944172	9.733558	10.266442	10.055827	10.322269	34
27	9.677964	9.944104	9.733860	10.266140	10.055896	10.322036	33
28	9.678197	9.944036	9.734162	10.265838	10.055964	10.321803	32
29	9.678430	9.943967	9.734463	10.265537	10.056033	10.321570	31
30	9.678663	9.943898	9.734764	10.265236	10.056101	10.321337	30
	Sine.		Tang.		Secant.		Min.

61 Degrees.

Tangents and Secants.

483

28 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.678663	9.943898	9.734764	10.265236	10.056101	10.321337
31	9.678895	9.943830	9.735066	10.264934	10.056170	10.321104
32	9.679128	9.943761	9.735367	10.264633	10.056239	10.320872
33	9.679360	9.943692	9.735668	10.264331	10.056307	10.320640
34	9.679592	9.943624	9.735968	10.264031	10.056376	10.320408
35	9.679824	9.943555	9.736269	10.263731	10.056445	10.320176
36	9.680056	9.943486	9.736570	10.263430	10.056514	10.319944
37	9.680288	9.943417	9.736870	10.263129	10.056583	10.319712
38	9.680519	9.943348	9.737171	10.262829	10.056652	10.319481
39	9.680750	9.943279	9.737471	10.262529	10.056721	10.319250
40	9.680982	9.943210	9.737771	10.262229	10.056790	10.319018
41	9.681213	9.943141	9.738071	10.261929	10.056859	10.318787
42	9.681443	9.943072	9.738371	10.261629	10.056928	10.318557
43	9.681674	9.943003	9.738671	10.261329	10.056997	10.318326
44	9.681905	9.942933	9.738971	10.261029	10.057066	10.318095
45	9.682135	9.942864	9.739271	10.260729	10.057136	10.317865
46	9.682365	9.942795	9.739570	10.260430	10.057205	10.317635
47	9.682595	9.942725	9.739870	10.260130	10.057274	10.317405
48	9.682825	9.942656	9.740169	10.259831	10.057344	10.317175
49	9.683055	9.942587	9.740468	10.259532	10.057413	10.316945
50	9.683284	9.942517	9.740767	10.259233	10.057483	10.316716
51	9.683514	9.942448	9.741066	10.258934	10.057552	10.316486
52	9.683743	9.942378	9.741365	10.258635	10.057622	10.316257
53	9.683972	9.942308	9.741664	10.258336	10.057691	10.316028
54	9.684201	9.942239	9.741962	10.258038	10.057761	10.315799
55	9.684430	9.942169	9.742261	10.257739	10.057831	10.315570
56	9.684650	9.942099	9.742559	10.257441	10.057901	10.315342
57	9.684887	9.942029	9.742858	10.257142	10.057971	10.315113
58	9.685115	9.941959	9.743156	10.256844	10.058041	10.314885
59	9.685343	9.941889	9.743454	10.256546	10.058111	10.314657
60	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429
	Sine.		Tang.		Secant.	Min.

61 Degrees.

K'k 2

29 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.085571	9.941819	9.741752	10.256248	10.058181	10.314429
1	9.685799	9.941749	9.744050	10.255950	10.058251	10.314201
2	9.686027	9.941679	9.744348	10.255652	10.058321	10.313973
3	9.686254	9.941609	9.744645	10.255355	10.058391	10.313746
4	9.686482	9.941539	9.744943	10.255057	10.058461	10.313518
5	9.686709	9.941468	9.745240	10.254760	10.058531	10.313291
6	9.686936	9.941398	9.745538	10.254462	10.058602	10.313064
7	9.687163	9.941328	9.745835	10.254165	10.058672	10.312837
8	9.687389	9.941257	9.746132	10.253868	10.058742	10.312610
9	9.687616	9.941187	9.746429	10.253571	10.058813	10.312384
10	9.687842	9.941117	9.746726	10.253274	10.058883	10.312157
11	9.688069	9.941046	9.747023	10.252977	10.058954	10.311931
12	9.688295	9.940975	9.747319	10.252681	10.059024	10.311705
13	9.688521	9.940905	9.747616	10.252384	10.059095	10.311479
14	9.688747	9.940834	9.747912	10.252087	10.059166	10.311253
15	9.688972	9.940763	9.748209	10.251791	10.059237	10.311028
16	9.689198	9.940693	9.748505	10.251495	10.059307	10.310802
17	9.689423	9.940622	9.748801	10.251199	10.059378	10.310577
18	9.689648	9.940551	9.749097	10.250903	10.059449	10.310352
19	9.689873	9.940480	9.749393	10.250607	10.059520	10.310127
20	9.690098	9.940409	9.749689	10.250311	10.059591	10.309902
21	9.690323	9.940338	9.749985	10.250015	10.059662	10.309677
22	9.690548	9.940267	9.750281	10.249719	10.059733	10.309452
23	9.690772	9.940196	9.750576	10.249424	10.059804	10.309228
24	9.690996	9.940125	9.750872	10.249128	10.059875	10.309004
25	9.691220	9.940053	9.751167	10.248833	10.059946	10.308779
26	9.691444	9.939982	9.751462	10.248538	10.060018	10.308555
27	9.691668	9.939911	9.751757	10.248243	10.060089	10.308332
28	9.691892	9.939840	9.752052	10.247948	10.060160	10.308108
29	9.692115	9.939768	9.752347	10.247653	10.060232	10.307884
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661
	Sine.		Tang.		Secant.	Min.

60 Degrees.

Tangents and Secants.

485

29 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.692339	9.939697	9.752042	10.247358	10.060303	10.307661	30
31	9.692562	9.939625	9.752937	10.247063	10.060375	10.307438	29
32	9.692785	9.939554	9.753231	10.246769	10.060446	10.307215	28
33	9.693009	9.939482	9.753526	10.246474	10.060518	10.306991	27
34	9.693231	9.939410	9.753820	10.246180	10.060589	10.306769	26
35	9.693453	9.939339	9.754115	10.245885	10.060661	10.306547	25
36	9.693676	9.939267	9.754409	10.245591	10.060733	10.306324	24
37	9.693898	9.939195	9.754703	10.245297	10.060805	10.306102	23
38	9.694120	9.939123	9.754997	10.245003	10.060877	10.305880	22
39	9.694342	9.939051	9.755291	10.244709	10.060948	10.305658	21
40	9.694564	9.938980	9.755585	10.244415	10.061020	10.305436	20
41	9.694786	9.938908	9.755878	10.244122	10.061092	10.305214	19
42	9.695007	9.938836	9.756172	10.243828	10.061164	10.304992	18
43	9.695229	9.938763	9.756465	10.243535	10.061236	10.304771	17
44	9.695450	9.938691	9.756759	10.243241	10.061309	10.304550	16
45	9.695671	9.938619	9.757052	10.242948	10.061381	10.304329	15
46	9.695892	9.938547	9.757345	10.242655	10.061453	10.304108	14
47	9.696113	9.938475	9.757638	10.242362	10.061525	10.303887	13
48	9.696334	9.938402	9.757931	10.242069	10.061598	10.303666	12
49	9.696554	9.938320	9.758224	10.241776	10.061670	10.303446	11
50	9.696774	9.938258	9.758517	10.241483	10.061742	10.303225	10
51	9.696995	9.938185	9.758810	10.241190	10.061815	10.303005	9
52	9.697215	9.938113	9.759102	10.240898	10.061887	10.302785	8
53	9.697435	9.938040	9.759395	10.240605	10.061960	10.302565	7
54	9.697654	9.937967	9.759687	10.240313	10.062033	10.302345	6
55	9.697874	9.937895	9.759979	10.240021	10.062105	10.302126	5
56	9.698094	9.937822	9.760272	10.239728	10.062178	10.301906	4
57	9.698313	9.937749	9.760564	10.239436	10.062251	10.301687	3
58	9.698532	9.937676	9.760856	10.239144	10.062324	10.301468	2
59	9.698751	9.937603	9.761148	10.238852	10.062396	10.301249	1
60	9.698970	9.937531	9.761439	10.238561	10.062469	10.301020	0
	Sine.		Tang.		Secant.		Min.

60 Degrees.

K k 3

30 Degrees.

Min.	Sine.		Tang		Secant.		
0	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	60
1	9.699189	9.937458	9.761731	10.238269	10.062543	10.300811	59
2	9.699407	9.937385	9.762023	10.237977	10.062615	10.300593	58
3	9.699526	9.937312	9.762314	10.237686	10.062688	10.300374	57
4	9.699844	9.937238	9.762606	10.237394	10.062761	10.300156	56
5	9.700062	9.937165	9.762897	10.237103	10.062835	10.299938	55
6	9.700280	9.937092	9.763188	10.236812	10.062908	10.299720	54
7	9.700498	9.936019	9.763479	10.236521	10.062981	10.299502	53
8	9.700716	9.936946	9.763770	10.236230	10.063054	10.299284	52
9	9.700933	9.936872	9.764061	10.235949	10.063128	10.299067	51
10	9.701151	9.936799	9.764352	10.235648	10.063201	10.298849	50
11	9.701368	9.936725	9.764643	10.235357	10.063275	10.298632	49
12	9.701585	9.936652	9.764933	10.235067	10.063348	10.298415	48
13	9.701802	9.936578	9.765224	10.234776	10.063422	10.298198	47
14	9.702019	9.936505	9.765514	10.234486	10.063495	10.297981	46
15	9.702236	9.936431	9.765805	10.234195	10.063569	10.297764	45
16	9.702452	9.936357	9.766095	10.233905	10.063643	10.297548	44
17	9.702669	9.936284	9.766385	10.233615	10.063716	10.297331	43
18	9.702885	9.936210	9.766675	10.233325	10.063790	10.297115	42
19	9.703101	9.936136	9.766965	10.233035	10.063864	10.296899	41
20	9.703317	9.936002	9.767255	10.232745	10.063938	10.296683	40
21	9.703533	9.935988	9.767545	10.232455	10.064012	10.296467	39
22	9.703749	9.935914	9.767834	10.232166	10.064086	10.296251	38
23	9.703964	9.935840	9.768124	10.231876	10.064160	10.296036	37
24	9.704179	9.935766	9.768413	10.231586	10.064234	10.295820	36
25	9.704395	9.935692	9.768703	10.231297	10.064308	10.295605	35
26	9.704610	9.935618	9.768992	10.231008	10.064382	10.295390	34
27	9.704825	9.935543	9.769281	10.230719	10.064457	10.295175	33
28	9.705040	9.935469	9.769570	10.230429	10.064531	10.294960	32
29	9.705254	9.935395	9.769860	10.230140	10.064605	10.294746	31
30	9.705469	9.935320	9.770148	10.229851	10.064680	10.294531	30
		Sine.		Tang.		Secant.	Min.

59 Degrees.

Tangents and Secants.

487

30 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.705469	9.935320	9.770148	10.229851	10.064680	10.294531	30
31	9.705683	9.935246	9.770437	10.229563	10.064754	10.294317	29
32	9.705897	9.935171	9.770726	10.229274	10.064828	10.294102	28
33	9.706112	9.935097	9.771015	10.228985	10.064903	10.293888	27
34	9.706326	9.935022	9.771303	10.228697	10.064978	10.293674	26
35	9.706539	9.934948	9.771592	10.228408	10.065052	10.293461	25
36	9.706753	9.934873	9.771880	10.228120	10.065127	10.293247	24
37	9.706967	9.934798	9.772168	10.227832	10.065202	10.293033	23
38	9.707180	9.934723	9.772457	10.227543	10.065276	10.292820	22
39	9.707393	9.934649	9.772745	10.227255	10.065351	10.292607	21
40	9.707606	9.934574	9.773033	10.226967	10.065426	10.292393	20
41	9.707819	9.934499	9.773321	10.226679	10.065501	10.292181	19
42	9.708032	9.934424	9.773608	10.226392	10.065576	10.291968	18
43	9.708245	9.934349	9.773896	10.226104	10.065651	10.291755	17
44	9.708457	9.934274	9.774184	10.225816	10.065726	10.291542	16
45	9.708670	9.934199	9.774471	10.225529	10.065801	10.291330	15
46	9.708882	9.934123	9.774759	10.225241	10.065877	10.291118	14
47	9.709094	9.934048	9.775046	10.224954	10.065952	10.290906	13
48	9.709306	9.933973	9.775333	10.224667	10.066027	10.290694	12
49	9.709518	9.933898	9.775621	10.224379	10.066102	10.290482	11
50	9.709730	9.933822	9.775908	10.224092	10.066178	10.290270	10
51	9.709941	9.933747	9.776195	10.223805	10.066253	10.290058	9
52	9.710153	9.933671	9.776482	10.223518	10.066329	10.289847	8
53	9.710364	9.933596	9.776768	10.223231	10.066404	10.289636	7
54	9.710575	9.933520	9.777055	10.222945	10.066480	10.289425	6
55	9.710786	9.933444	9.777342	10.222658	10.066555	10.289214	5
56	9.710997	9.933369	9.777628	10.222372	10.066631	10.289003	4
57	9.711208	9.933293	9.777915	10.222085	10.066707	10.288792	3
58	9.711419	9.933217	9.778201	10.221799	10.066783	10.288581	2
59	9.711629	9.933141	9.778487	10.221512	10.066858	10.288371	1
60	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	0
	Sine.		Tang.		Secant.		Min.

59 Degrees.

K k 4

31 Degrees.

Min.	Sine.		Tang		Secant.		
0	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	60
1	9.712049	9.932990	9.779060	10.220940	10.067010	10.287950	59
2	9.712260	9.932914	9.779346	10.220654	10.067086	10.287740	58
3	9.712469	9.932838	9.779632	10.220368	10.067162	10.287530	57
4	9.712679	9.932762	9.779918	10.220082	10.067238	10.287321	56
5	9.712889	9.932685	9.780203	10.219797	10.067315	10.287111	55
6	9.713098	9.932609	9.780489	10.219511	10.067391	10.286902	54
7	9.713308	9.932533	9.780775	10.219225	10.067467	10.286692	53
8	9.713517	9.932457	9.781060	10.218940	10.067543	10.286482	52
9	9.713726	9.932380	9.781346	10.218654	10.067620	10.286274	51
10	9.713935	9.932304	9.781631	10.218369	10.067696	10.286065	50
11	9.714144	9.932228	9.781916	10.218084	10.067772	10.285856	49
12	9.714352	9.932151	9.782201	10.217799	10.067849	10.285648	48
13	9.714561	9.932075	9.782486	10.217514	10.067925	10.285439	47
14	9.714769	9.931998	9.782771	10.217229	10.068002	10.285231	46
15	9.714978	9.931921	9.783056	10.216944	10.068079	10.285022	45
16	9.715186	9.931845	9.783341	10.216660	10.068155	10.284814	44
17	9.715394	9.931768	9.783626	10.216374	10.068232	10.284606	43
18	9.715601	9.931691	9.783910	10.216090	10.068309	10.284398	42
19	9.715809	9.931614	9.784195	10.215805	10.068386	10.284191	41
20	9.716017	9.931537	9.784479	10.215521	10.068463	10.283983	40
21	9.716224	9.931460	9.784764	10.215235	10.068539	10.283776	39
22	9.716432	9.931383	9.785048	10.214952	10.068616	10.283568	38
23	9.716639	9.931306	9.785332	10.214668	10.068693	10.283361	37
24	9.716846	9.931229	9.785616	10.214384	10.068771	10.283154	36
25	9.717053	9.931152	9.785900	10.214100	10.068848	10.282947	35
26	9.717259	9.931075	9.786184	10.213816	10.068925	10.282741	34
27	9.717466	9.930998	9.786468	10.213532	10.069002	10.282534	33
28	9.717672	9.930920	9.786752	10.213248	10.069079	10.282327	32
29	9.717879	9.930843	9.787036	10.212964	10.069157	10.282121	31
30	9.718085	9.930766	9.787310	10.212681	10.069234	10.281915	30
	Sine.		Tang.		Secant.		Min.

58 Degrees.

Tangents and Secants.

489

31 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281915	30
31	9.718291	9.930688	9.787603	10.212397	10.069312	10.281709	29
32	9.718497	9.930611	9.787886	10.212114	10.069389	10.281503	28
33	9.718703	9.930533	9.788170	10.211830	10.069467	10.281297	27
34	9.718909	9.930456	9.788453	10.211547	10.069544	10.281091	26
35	9.719114	9.930378	9.788736	10.211264	10.069622	10.280886	25
36	9.719320	9.930300	9.789019	10.210981	10.069700	10.280680	24
37	9.719525	9.930223	9.789302	10.210698	10.069777	10.280475	23
38	9.719730	9.930145	9.789585	10.210415	10.069855	10.280270	22
39	9.719935	9.930067	9.789868	10.210132	10.069933	10.280065	21
40	9.720140	9.929989	9.790151	10.209849	10.070011	10.279860	20
41	9.720345	9.929911	9.790433	10.209566	10.070089	10.279655	19
42	9.720549	9.929833	9.790716	10.209284	10.070167	10.279451	18
43	9.720754	9.929755	9.790999	10.209001	10.070244	10.279246	17
44	9.720958	9.929677	9.791281	10.208719	10.070323	10.279042	16
45	9.721162	9.929599	9.791563	10.208436	10.070401	10.278838	15
46	9.721366	9.929521	9.791846	10.208154	10.070479	10.278634	14
47	9.721570	9.929442	9.792128	10.207872	10.070558	10.278430	13
48	9.721774	9.929364	9.792410	10.207590	10.070636	10.278226	12
49	9.721978	9.929286	9.792692	10.207308	10.070714	10.278022	11
50	9.722181	9.929207	9.792974	10.207026	10.070793	10.277819	10
51	9.722385	9.929129	9.793256	10.206744	10.070871	10.277615	9
52	9.722588	9.929050	9.793538	10.206462	10.070950	10.277412	8
53	9.722791	9.928972	9.793819	10.206180	10.071028	10.277209	7
54	9.722994	9.928893	9.794101	10.205899	10.071107	10.277006	6
55	9.723197	9.928814	9.794383	10.205617	10.071185	10.276803	5
56	9.723400	9.928736	9.794664	10.205336	10.071264	10.276600	4
57	9.723603	9.928657	9.794945	10.205054	10.071343	10.276397	3
58	9.723805	9.928578	9.795227	10.204773	10.071422	10.276195	2
59	9.724007	9.928499	9.795508	10.204492	10.071501	10.275992	1
60	9.724210	9.928420	9.795789	10.204211	10.071579	10.275790	0
	Sine.		Tang.		Secant.		

58 Degrees.

32 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.724210	9.928420	9.795789	10.204211	10.071579	10.275790
1	9.724412	9.928341	9.796070	10.203930	10.071658	10.275588
2	9.724614	9.928262	9.796351	10.203649	10.071737	10.275386
3	9.724816	9.928183	9.796632	10.203368	10.071817	10.275184
4	9.725017	9.928104	9.796913	10.203087	10.071896	10.274983
5	9.725219	9.928025	9.797194	10.202806	10.071975	10.274781
6	9.725420	9.927946	9.797474	10.202525	10.072054	10.274580
7	9.725622	9.927867	9.797755	10.202245	10.072133	10.274378
8	9.725823	9.927787	9.798036	10.201964	10.072213	10.274177
9	9.726024	9.927708	9.798316	10.201684	10.072292	10.273976
10	9.726225	9.927628	9.798596	10.201404	10.072371	10.273775
11	9.726426	9.927549	9.798877	10.201123	10.072451	10.273574
12	9.726626	9.927469	9.799157	10.200843	10.072530	10.273374
13	9.726827	9.927390	9.799437	10.200563	10.072610	10.273173
14	9.727027	9.927310	9.799717	10.200283	10.072690	10.272973
15	9.727228	9.927231	9.799997	10.200003	10.072769	10.272772
16	9.727428	9.927151	9.800277	10.199723	10.072849	10.272572
17	9.727628	9.927071	9.800557	10.199443	10.072929	10.272372
18	9.727828	9.926991	9.800836	10.199163	10.073009	10.272172
19	9.728027	9.926911	9.801116	10.198884	10.073089	10.271972
20	9.728227	9.926831	9.801396	10.198604	10.073169	10.271773
21	9.728427	9.926751	9.801675	10.198325	10.073249	10.271573
22	9.728626	9.926671	9.801955	10.198045	10.073329	10.271374
23	9.728825	9.926591	9.802234	10.197766	10.073409	10.271175
24	9.729024	9.926511	9.802513	10.197487	10.073489	10.270976
25	9.729223	9.926431	9.802792	10.197207	10.073569	10.270777
26	9.729422	9.926351	9.803072	10.196928	10.073649	10.270578
27	9.729621	9.926270	9.803351	10.196649	10.073730	10.270379
28	9.729820	9.926190	9.803630	10.196370	10.073810	10.270180
29	9.730018	9.926110	9.803908	10.196091	10.073890	10.269982
30	9.730216	9.926029	9.804187	10.195812	10.073970	10.269783
	Sine.		Tang.		Secant.	Min.

57 Degrees.

Tangents and Secants.

491

32 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.730216	9.926029	9.804187	10.195813	10.073976	10.269783	30
31	9.730415	9.925949	9.804466	10.195534	10.074051	10.269583	29
32	9.730613	9.925868	9.804745	10.195255	10.074132	10.269387	28
33	9.730811	9.925787	9.805023	10.194977	10.074212	10.269189	27
34	9.731009	9.925707	9.805302	10.194698	10.074293	10.268991	26
35	9.731206	9.925626	9.805580	10.194420	10.074374	10.268794	25
36	9.731404	9.925545	9.805859	10.194141	10.074455	10.268596	24
37	9.731601	9.925465	9.806137	10.193863	10.074535	10.268398	23
38	9.731799	9.925384	9.806415	10.193585	10.074616	10.268201	22
39	9.731996	9.925303	9.806693	10.193307	10.074697	10.268004	21
40	9.732193	9.925222	9.806971	10.193029	10.074778	10.267807	20
41	9.732390	9.925141	9.807249	10.192751	10.074859	10.267601	19
42	9.732587	9.925060	9.807527	10.192473	10.074940	10.267413	18
43	9.732784	9.924979	9.807805	10.192195	10.075021	10.267216	17
44	9.732981	9.924897	9.808083	10.191917	10.075102	10.267020	16
45	9.733177	9.924816	9.808361	10.191639	10.075184	10.266823	15
46	9.733372	9.924735	9.808638	10.191362	10.075265	10.266627	14
47	9.733569	9.924653	9.808916	10.191084	10.075346	10.266431	13
48	9.733765	9.924572	9.809193	10.190807	10.075428	10.266235	12
49	9.733961	9.924491	9.809471	10.190529	10.075509	10.266039	11
50	9.734157	9.924409	9.809748	10.190252	10.075591	10.265843	10
51	9.734353	9.924328	9.810025	10.189975	10.075672	10.265647	9
52	9.734548	9.924246	9.810302	10.189697	10.075754	10.265451	8
53	9.734744	9.924164	9.810580	10.189420	10.075836	10.265256	7
54	9.734939	9.924083	9.810857	10.189143	10.075917	10.265061	6
55	9.735134	9.924001	9.811134	10.188866	10.075999	10.264865	5
56	9.735330	9.923919	9.811410	10.188589	10.076081	10.264670	4
57	9.735525	9.923837	9.811687	10.188313	10.076163	10.264475	3
58	9.735719	9.923755	9.811964	10.188036	10.076245	10.264280	2
59	9.735914	9.923673	9.812241	10.187759	10.076327	10.264086	1
60	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	0
	Sine.		Tang.		Secant.		Min.

57 Degrees.

33 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
0	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	60
1	9.736303	9.923509	9.812794	10.187206	10.076491	10.263697	59
2	9.736498	9.923427	9.813070	10.186930	10.076573	10.263502	58
3	9.736692	9.923345	9.813347	10.186653	10.076655	10.263308	57
4	9.736886	9.923263	9.813622	10.186377	10.076737	10.263114	56
5	9.737080	9.923180	9.813899	10.186101	10.076819	10.262920	55
6	9.737274	9.923098	9.814175	10.185824	10.076902	10.262726	54
7	9.737467	9.923016	9.814452	10.185548	10.076984	10.262532	53
8	9.737661	9.922933	9.814728	10.185272	10.077057	10.262339	52
9	9.737855	9.922851	9.815004	10.185006	10.077140	10.262145	51
10	9.738048	9.922768	9.815279	10.184720	10.077222	10.261952	50
11	9.738241	9.922686	9.815555	10.184445	10.077314	10.261758	49
12	9.738434	9.922603	9.815831	10.184169	10.077397	10.261566	48
13	9.738627	9.922520	9.816107	10.183892	10.077479	10.261373	47
14	9.738820	9.922438	9.816382	10.183618	10.077562	10.261180	46
15	9.739013	9.922355	9.816658	10.183342	10.077645	10.260987	45
16	9.739205	9.922272	9.816933	10.183066	10.077728	10.260794	44
17	9.739398	9.922189	9.817209	10.182791	10.077811	10.260602	43
18	9.739590	9.922105	9.817484	10.182516	10.077894	10.260410	42
19	9.739783	9.922023	9.817759	10.182240	10.077977	10.260217	41
20	9.739975	9.921940	9.818035	10.181965	10.078060	10.260025	40
21	9.740167	9.921857	9.818310	10.181690	10.078143	10.259833	39
22	9.740359	9.921774	9.818585	10.181415	10.078226	10.259641	38
23	9.740550	9.921691	9.818860	10.181140	10.078309	10.259449	37
24	9.740742	9.921607	9.819135	10.180865	10.078393	10.259258	36
25	9.740934	9.921524	9.819410	10.180590	10.078476	10.259066	35
26	9.741125	9.921441	9.819684	10.180316	10.078559	10.258875	34
27	9.741316	9.921357	9.819959	10.180041	10.078643	10.258684	33
28	9.741507	9.921274	9.820234	10.179766	10.078726	10.258492	32
29	9.741699	9.921190	9.820508	10.179492	10.078810	10.258301	31
30	9.741880	9.921107	9.820783	10.179217	10.078893	10.258110	30
		Sine.		Tang.		Secant.	Min.

56 Degrees.

Tangents and Secants.

493

33 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258110	30
31	9.742080	9.921023	9.821057	10.178943	10.078977	10.257920	29
32	9.742271	9.920939	9.821332	10.178668	10.079061	10.257729	28
33	9.742462	9.920855	9.821606	10.178394	10.079144	10.257538	27
34	9.742652	9.920772	9.821880	10.178120	10.079228	10.257348	26
35	9.742842	9.920688	9.822154	10.177845	10.079312	10.257158	25
36	9.743032	9.920604	9.822429	10.177571	10.079396	10.256967	24
37	9.743222	9.920520	9.822703	10.177297	10.079480	10.256777	23
38	9.743412	9.920436	9.822977	10.177023	10.079564	10.256587	22
39	9.743602	9.920352	9.823250	10.176749	10.079648	10.256398	21
40	9.743792	9.920268	9.823524	10.176476	10.079732	10.256208	20
41	9.743982	9.920184	9.823798	10.176202	10.079816	10.256018	19
42	9.744171	9.920099	9.824072	10.175928	10.079901	10.255829	18
43	9.744361	9.920015	9.824345	10.175654	10.079985	10.255639	17
44	9.744550	9.919931	9.824619	10.175381	10.080069	10.255450	16
45	9.744739	9.919846	9.824893	10.175107	10.080154	10.255261	15
46	9.744928	9.919762	9.825166	10.174834	10.080238	10.255072	14
47	9.745117	9.919677	9.825439	10.174561	10.080322	10.254883	13
48	9.745306	9.919593	9.825713	10.174287	10.080407	10.254694	12
49	9.745494	9.919508	9.825986	10.174014	10.080492	10.254506	11
50	9.745683	9.919424	9.826259	10.173741	10.080576	10.254317	10
51	9.745871	9.919339	9.826532	10.173468	10.080661	10.254129	9
52	9.746059	9.919254	9.826805	10.173195	10.080746	10.253940	8
53	9.746248	9.919169	9.827078	10.172922	10.080831	10.253752	7
54	9.746436	9.919084	9.827351	10.172649	10.080915	10.253564	6
55	9.746624	9.919000	9.827624	10.172376	10.081000	10.253376	5
56	9.746811	9.918915	9.827897	10.172103	10.081085	10.253188	4
57	9.746999	9.918830	9.828170	10.171830	10.081170	10.253001	3
58	9.747187	9.918744	9.828442	10.171558	10.081255	10.252813	2
59	9.747374	9.918659	9.828715	10.171285	10.081341	10.252626	1
60	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	0
	Sine.		Tang.		Secant.		

56 Degrees.

34 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438
1	9.747742	9.918489	9.829260	10.170740	10.081511	10.252451
2	9.747936	9.918404	9.829532	10.170468	10.081596	10.252064
3	9.748123	9.918318	9.829805	10.170195	10.081682	10.251877
4	9.748309	9.918233	9.830077	10.169923	10.081767	10.251690
5	9.748497	9.918147	9.830349	10.169651	10.081852	10.251503
6	9.748683	9.918062	9.830621	10.169379	10.081938	10.251317
7	9.748870	9.917976	9.830893	10.169107	10.082024	10.251130
8	9.749056	9.917891	9.831165	10.168835	10.082109	10.250944
9	9.749242	9.917805	9.831437	10.168563	10.082195	10.250757
10	9.749429	9.917719	9.831709	10.168291	10.082281	10.250571
11	9.749615	9.917634	9.831981	10.168019	10.082366	10.250385
12	9.749801	9.917548	9.832253	10.167747	10.082452	10.250199
13	9.749987	9.917462	9.832525	10.167475	10.082538	10.250013
14	9.750172	9.917376	9.832796	10.167204	10.082624	10.249828
15	9.750358	9.917290	9.833068	10.166932	10.082710	10.249642
16	9.750543	9.917204	9.833339	10.166661	10.082796	10.249457
17	9.750729	9.917118	9.833611	10.166389	10.082882	10.249271
18	9.750914	9.917032	9.833882	10.166118	10.082968	10.249086
19	9.751099	9.916945	9.834154	10.165846	10.083054	10.248901
20	9.751284	9.916859	9.834425	10.165575	10.083141	10.248716
21	9.751469	9.916773	9.834696	10.165304	10.083227	10.248531
22	9.751654	9.916687	9.834967	10.165033	10.083313	10.248346
23	9.751838	9.916600	9.835238	10.164762	10.083400	10.248161
24	9.752023	9.916514	9.835509	10.164491	10.083486	10.247977
25	9.752207	9.916427	9.835780	10.164220	10.083573	10.247792
26	9.752392	9.916341	9.836051	10.163949	10.083659	10.247608
27	9.752576	9.916254	9.836322	10.163678	10.083746	10.247424
28	9.752760	9.916167	9.836593	10.163407	10.083833	10.247240
29	9.752944	9.916080	9.836864	10.163136	10.083919	10.247056
30	9.753128	9.915994	9.837135	10.162866	10.084006	10.246872
	Sine.		Tang.		Secant.	Min.

55 Degrees.

Tangents and Secants.

495

34 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.753128	9.915994	9.837134	10.162866
31	9.753312	9.915907	9.837405	10.162595
32	9.753495	9.915820	9.837675	10.162324
33	9.753679	9.915733	9.837946	10.162054
34	9.753862	9.915646	9.838216	10.161784
35	9.754046	9.915559	9.838487	10.161513
36	9.754229	9.915472	9.838757	10.161243
37	9.754412	9.915385	9.839027	10.160973
38	9.754595	9.915297	9.839297	10.160702
39	9.754778	9.915210	9.839568	10.160432
40	9.754960	9.915123	9.839838	10.160162
41	9.755143	9.915035	9.840108	10.159892
42	9.755326	9.914948	9.840378	10.159622
43	9.755508	9.914860	9.840647	10.159352
44	9.755690	9.914773	9.840917	10.159083
45	9.755872	9.914685	9.841187	10.158813
46	9.756054	9.914598	9.841457	10.158543
47	9.756236	9.914510	9.841726	10.158273
48	9.756418	9.914422	9.841996	10.158004
49	9.756600	9.914334	9.842266	10.157734
50	9.756781	9.914246	9.842535	10.157465
51	9.75696	9.914158	9.842805	10.157195
52	9.757144	9.914070	9.843074	10.156926
53	9.757326	9.913982	9.843343	10.156657
54	9.757507	9.913894	9.843612	10.156388
55	9.757688	9.913806	9.843882	10.156118
56	9.757869	9.913718	9.844151	10.155849
57	9.758049	9.913630	9.844420	10.155580
58	9.758230	9.913541	9.844689	10.155311
59	9.758411	9.913453	9.844958	10.155042
60	9.758591	9.913364	9.845227	10.154773
	Sine.	Tang.	Secant.	Min.

55 Degrees.

35 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.758591	9.913364	9.845227	10.154773	10.086635	10.241409
1	9.758772	9.913276	9.845496	10.154504	10.086724	10.241228
2	9.758952	9.913187	9.845764	10.154236	10.086812	10.241048
3	9.759132	9.913099	9.846033	10.153967	10.086901	10.240868
4	9.759312	9.913010	9.846302	10.153698	10.086990	10.240688
5	9.759492	9.912921	9.846570	10.153429	10.087078	10.240508
6	9.759672	9.912833	9.846839	10.153161	10.087167	10.240328
7	9.759851	9.912744	9.847107	10.152892	10.087256	10.240148
8	9.760031	9.912655	9.847376	10.152624	10.087345	10.239969
9	9.760211	9.912566	9.847644	10.152356	10.087434	10.239789
10	9.760390	9.912477	9.847913	10.152087	10.087523	10.239610
11	9.760569	9.912388	9.848181	10.151819	10.087612	10.239431
12	9.760748	9.912299	9.848449	10.151551	10.087701	10.239252
13	9.760927	9.912210	9.848717	10.151283	10.087790	10.239073
14	9.761106	9.912121	9.848985	10.151014	10.087879	10.238894
15	9.761285	9.912031	9.849254	10.150746	10.087968	10.238715
16	9.761464	9.911942	9.849522	10.150478	10.088058	10.238536
17	9.761642	9.911853	9.849790	10.150210	10.088147	10.238358
18	9.761821	9.911763	9.850057	10.149942	10.088237	10.238179
19	9.761999	9.911674	9.850325	10.149675	10.088326	10.238001
20	9.762177	9.911584	9.850593	10.149407	10.088416	10.237822
21	9.762356	9.911495	9.850861	10.149139	10.088505	10.237644
22	9.762534	9.911405	9.851128	10.148871	10.088595	10.237466
23	9.762712	9.911315	9.851396	10.148604	10.088684	10.237288
24	9.762890	9.911226	9.851664	10.148336	10.088774	10.237111
25	9.763067	9.911136	9.851931	10.148069	10.088864	10.236933
26	9.763245	9.911046	9.852199	10.147801	10.088954	10.236755
27	9.763422	9.910956	9.852466	10.147534	10.089044	10.236578
28	9.763600	9.910866	9.852733	10.147266	10.089134	10.236400
29	9.763777	9.910776	9.853001	10.146999	10.089224	10.236223
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046
	Sine.		Tang.		Secant.	Min.

54 Degrees.

35 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
30	9.763954	9.910686	10.146732	30
31	9.764131	9.910596	10.146465	29
32	9.764308	9.910506	10.146198	28
33	9.764485	9.910415	10.145931	27
34	9.764662	9.910325	10.145664	26
35	9.764838	9.910235	10.145397	25
36	9.765015	9.910144	10.145130	24
37	9.765191	9.910054	10.144863	23
38	9.765367	9.909963	10.144596	22
39	9.765544	9.909873	10.144329	21
40	9.765720	9.909782	10.144062	20
41	9.765896	9.909691	10.143796	19
42	9.766071	9.909601	10.143529	18
43	9.766247	9.909510	10.143263	17
44	9.766423	9.909419	10.142996	16
45	9.766598	9.909328	10.142730	15
46	9.766774	9.909237	10.142463	14
47	9.766949	9.909146	10.142197	13
48	9.767124	9.909055	10.141931	12
49	9.767299	9.908964	10.141664	11
50	9.767475	9.908873	10.141398	10
51	9.767649	9.908781	10.141132	9
52	9.767824	9.908691	10.140866	8
53	9.767999	9.908599	10.140600	7
54	9.768173	9.908507	10.140334	6
55	9.768348	9.908416	10.140068	5
56	9.768522	9.908324	10.139802	4
57	9.768697	9.908233	10.139536	3
58	9.768871	9.908141	10.139270	2
59	9.769045	9.908049	10.139005	1
60	9.769219	9.907958	10.138739	0
	Sine.	Tang.	Secant.	Min.

54 Degrees.

L 1

36 Degrees.

Min.	Sine.	Tang.	Secant.	Min.
0	9.709219	9.907958	9.861261	10.138739
1	9.709392	9.907866	9.861327	10.138477
2	9.709566	9.907774	9.861392	10.138208
3	9.709740	9.907682	9.861458	10.137942
4	9.709913	9.907590	9.861522	10.137677
5	9.770087	9.907498	9.861586	10.137411
6	9.770260	9.907406	9.861651	10.137146
7	9.770433	9.907314	9.861716	10.136880
8	9.770606	9.907221	9.861781	10.136615
9	9.770779	9.907129	9.861845	10.136350
10	9.770952	9.907037	9.861910	10.136085
11	9.771125	9.906945	9.861975	10.135820
12	9.771298	9.906852	9.862040	10.135555
13	9.771470	9.906760	9.862105	10.135289
14	9.771642	9.906667	9.862170	10.135024
15	9.771815	9.906574	9.862235	10.134760
16	9.771987	9.906482	9.862300	10.134495
17	9.772159	9.906389	9.862365	10.134230
18	9.772331	9.906296	9.862430	10.133965
19	9.772503	9.906204	9.862495	10.133700
20	9.772675	9.906111	9.862560	10.133435
21	9.772847	9.906018	9.862625	10.133170
22	9.773019	9.905925	9.862690	10.132905
23	9.773190	9.905832	9.862755	10.132640
24	9.773362	9.905739	9.862820	10.132375
25	9.773533	9.905645	9.862885	10.132110
26	9.773704	9.905552	9.862950	10.131845
27	9.773875	9.905459	9.863015	10.131580
28	9.774046	9.905366	9.863080	10.131315
29	9.774217	9.905272	9.863145	10.131050
30	9.774388	9.905179	9.863209	10.130785
	Sine.	Tang.	Secant.	Min.

53 Degrees.

Tangents and Secants.

499

36 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612
31	9.774538	9.905085	9.869473	10.130527	10.094915	10.225442
32	9.774729	9.904992	9.869737	10.130263	10.095008	10.225271
33	9.774899	9.904898	9.870001	10.129999	10.095162	10.225101
34	9.775070	9.904804	9.870265	10.129735	10.095196	10.224930
35	9.775240	9.904711	9.870529	10.129471	10.095289	10.224760
36	9.775410	9.904617	9.870793	10.129207	10.095383	10.224590
37	9.775580	9.904523	9.871057	10.128943	10.095477	10.224420
38	9.775750	9.904429	9.871321	10.128679	10.095571	10.224250
39	9.775920	9.904335	9.871585	10.128415	10.095665	10.224080
40	9.776090	9.904241	9.871849	10.128151	10.095759	10.223910
41	9.776259	9.904147	9.872112	10.127888	10.095853	10.223741
42	9.776429	9.904053	9.872376	10.127624	10.095947	10.223571
43	9.776598	9.903959	9.872640	10.127360	10.096041	10.223402
44	9.776768	9.903864	9.872903	10.127097	10.096136	10.223232
45	9.776937	9.903770	9.873167	10.126833	10.096230	10.223063
46	9.777106	9.903676	9.873430	10.126570	10.096324	10.222894
47	9.777275	9.903581	9.873694	10.126306	10.096419	10.222725
48	9.777444	9.903487	9.873957	10.126042	10.096513	10.222556
49	9.777613	9.903392	9.874220	10.125780	10.096608	10.222387
50	9.777781	9.903298	9.874484	10.125516	10.096703	10.222218
51	9.777950	9.903203	9.874747	10.125253	10.096797	10.222055
52	9.778119	9.903108	9.875010	10.124990	10.096892	10.221881
53	9.778287	9.903014	9.875273	10.124727	10.096986	10.221713
54	9.778455	9.902919	9.875536	10.124463	10.097081	10.221545
55	9.778623	9.902824	9.875800	10.124200	10.097176	10.221376
56	9.778792	9.902729	9.876063	10.123937	10.097271	10.221208
57	9.778960	9.902634	9.876326	10.123674	10.097366	10.221040
58	9.779128	9.902539	9.876589	10.123411	10.097461	10.220872
59	9.779295	9.902444	9.876851	10.123148	10.097556	10.220705
60	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537
	Sine.		Tang.		Secant.	

53 Degrees.

L 1 2

37 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.77940	9.902349	9.877114	10.122886	10.097651	10.220537
1	9.77973	9.902253	9.877377	10.122623	10.097747	10.220369
2	9.77998	9.902158	9.877640	10.122360	10.097842	10.220202
3	9.779965	9.902063	9.877903	10.122097	10.097937	10.220034
4	9.780122	9.901967	9.878165	10.121835	10.098033	10.219867
5	9.78030	9.901872	9.878428	10.121572	10.098128	10.219700
6	9.780467	9.901776	9.878691	10.121309	10.098224	10.219533
7	9.780634	9.901681	9.878953	10.121047	10.098319	10.219366
8	9.780801	9.901585	9.879216	10.120784	10.098415	10.219199
9	9.780978	9.901489	9.879478	10.120522	10.098510	10.219032
10	9.781144	9.901394	9.879741	10.120259	10.098606	10.218866
11	9.781301	9.901298	9.880003	10.119997	10.098702	10.218699
12	9.781467	9.901202	9.880265	10.119735	10.098798	10.218532
13	9.781634	9.901106	9.880528	10.119472	10.098894	10.218366
14	9.781800	9.901010	9.880790	10.119210	10.098990	10.218200
15	9.781966	9.900914	9.881052	10.118948	10.099086	10.218034
16	9.782132	9.900818	9.881314	10.118686	10.099182	10.217868
17	9.782298	9.900721	9.881576	10.118423	10.099278	10.217702
18	9.782464	9.900626	9.881839	10.118161	10.099374	10.217536
19	9.782630	9.900529	9.882101	10.117899	10.099471	10.217370
20	9.782796	9.900433	9.882363	10.117637	10.099567	10.217204
21	9.782961	9.900337	9.882625	10.117375	10.099663	10.217039
22	9.783127	9.900240	9.882887	10.117113	10.099760	10.216873
23	9.783292	9.900144	9.883148	10.116852	10.099856	10.216708
24	9.783457	9.900047	9.883410	10.116590	10.099953	10.216542
25	9.783621	9.899951	9.883672	10.116328	10.100049	10.216377
26	9.783788	9.899854	9.883934	10.116066	10.100146	10.216212
27	9.783953	9.899757	9.884196	10.115804	10.100242	10.216047
28	9.784118	9.899660	9.884457	10.115543	10.100340	10.215882
29	9.784282	9.899564	9.884719	10.115281	10.100437	10.215718
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553
	Sine.		Tang.		Secant.	Min.

52 Degrees.

Tangents and Secants.

501

37 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.784447	9.899467	9.884980	10.115019	10.100533	10.215553	30
31	9.784612	9.899370	9.885242	10.114758	10.100630	10.215388	29
32	9.784776	9.899273	9.885503	10.114496	10.100727	10.215224	28
33	9.784941	9.899176	9.885765	10.114235	10.100824	10.215059	27
34	9.785105	9.899078	9.886026	10.113974	10.100922	10.214895	26
35	9.785269	9.898981	9.886288	10.113712	10.101019	10.214731	25
36	9.785433	9.898884	9.886549	10.113450	10.101116	10.214567	24
37	9.785597	9.898787	9.886810	10.113189	10.101213	10.214403	23
38	9.785761	9.898689	9.887072	10.112928	10.101311	10.214239	22
39	9.785925	9.898592	9.887333	10.112667	10.101408	10.214075	21
40	9.786089	9.898494	9.887594	10.112406	10.101506	10.213911	20
41	9.786252	9.898397	9.887855	10.112145	10.101603	10.213748	19
42	9.786416	9.898299	9.888116	10.111883	10.101701	10.213584	18
43	9.786579	9.898201	9.888377	10.111622	10.101798	10.213420	17
44	9.786742	9.898104	9.888639	10.111361	10.101896	10.213258	16
45	9.786906	9.898006	9.888900	10.111100	10.101994	10.213094	15
46	9.787069	9.897908	9.889160	10.110839	10.102092	10.212931	14
47	9.787232	9.897810	9.889421	10.110579	10.102190	10.212768	13
48	9.787395	9.897712	9.889682	10.110318	10.102288	10.212605	12
49	9.787557	9.897614	9.889943	10.110057	10.102386	10.212443	11
50	9.787720	9.897516	9.890204	10.109796	10.102484	10.212280	10
51	9.787883	9.897418	9.890465	10.109535	10.102582	10.212117	9
52	9.788045	9.897320	9.890725	10.109275	10.102680	10.211955	8
53	9.788208	9.897222	9.890986	10.109014	10.102778	10.211792	7
54	9.788370	9.897123	9.891247	10.108753	10.102877	10.211630	6
55	9.788532	9.897025	9.891507	10.108492	10.102975	10.211467	5
56	9.788694	9.896926	9.891768	10.108232	10.103073	10.211305	4
57	9.788856	9.896828	9.892028	10.107971	10.103172	10.211143	3
58	9.789018	9.896729	9.892289	10.107711	10.103271	10.210982	2
59	9.789180	9.896631	9.892549	10.107451	10.103369	10.210820	1
60	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	0
	Sine.		Tang.		Secant.		Min.

52 Degrees.

L13

38 Degrees.

Min.	Sine.		Tang		Secant.		
0	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	60
1	9.789504	9.896433	9.893070	10.106930	10.103567	10.210496	59
2	9.789665	9.896335	9.893331	10.106669	10.103665	10.210335	58
3	9.789827	9.896236	9.893591	10.106409	10.103764	10.210173	57
4	9.789988	9.896137	9.893851	10.106149	10.103863	10.210012	56
5	9.790149	9.896038	9.894111	10.105889	10.103962	10.209851	55
6	9.790310	9.895939	9.894371	10.105628	10.104061	10.209690	54
7	9.790471	9.895840	9.894632	10.105368	10.104160	10.209528	53
8	9.790632	9.895741	9.894892	10.105108	10.104259	10.209367	52
9	9.790793	9.895641	9.895152	10.104848	10.104359	10.209207	51
10	9.790954	9.895542	9.895412	10.104588	10.104458	10.209046	50
11	9.791115	9.895443	9.895672	10.104328	10.104557	10.208885	49
12	9.791275	9.895343	9.895932	10.104068	10.104656	10.208725	48
13	9.791436	9.895244	9.896192	10.103808	10.104756	10.208564	47
14	9.791596	9.895144	9.896452	10.103548	10.104855	10.208404	46
15	9.791757	9.895045	9.896712	10.103288	10.104955	10.208243	45
16	9.791917	9.894945	9.896971	10.103029	10.105055	10.208083	44
17	9.792077	9.894846	9.897231	10.102769	10.105154	10.207923	43
18	9.792237	9.894746	9.897491	10.102509	10.105254	10.207763	42
19	9.792397	9.894646	9.897751	10.102249	10.105354	10.207603	41
20	9.792557	9.894546	9.898010	10.101990	10.105454	10.207443	40
21	9.792716	9.894445	9.898270	10.101730	10.105554	10.207284	39
22	9.792876	9.894346	9.898530	10.101470	10.105654	10.207124	38
23	9.793035	9.894246	9.898789	10.101211	10.105754	10.206964	37
24	9.793195	9.894146	9.899049	10.100951	10.105854	10.206805	36
25	9.793354	9.894046	9.899308	10.100692	10.105954	10.206646	35
26	9.793513	9.893946	9.899568	10.100432	10.106054	10.206486	34
27	9.793673	9.893846	9.899827	10.100173	10.106154	10.206327	33
28	9.793832	9.893745	9.900086	10.099913	10.106255	10.206168	32
29	9.793991	9.893645	9.900346	10.099654	10.106355	10.206009	31
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
	Sine.		Tang.		Secant.		Min.

51 Degrees.

Tangents and Secants.

503

38 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.794150	9.893344	9.900605	10.099195	10.106456	10.205850	30
31	9.794308	9.893444	9.900864	10.099135	10.106556	10.205692	29
32	9.794467	9.893543	9.901124	10.098876	10.106657	10.205533	28
33	9.794626	9.893643	9.901383	10.098617	10.106757	10.205374	27
34	9.794784	9.893742	9.901642	10.098358	10.106858	10.205216	26
35	9.794942	9.893841	9.901901	10.098099	10.106959	10.205057	25
36	9.795101	9.893940	9.902160	10.097840	10.107060	10.204899	24
37	9.795259	9.894039	9.902419	10.097580	10.107160	10.204741	23
38	9.795417	9.894138	9.902679	10.097321	10.107261	10.204581	22
39	9.795575	9.894237	9.902938	10.097062	10.107362	10.204425	21
40	9.795733	9.894336	9.903197	10.096803	10.107463	10.204267	20
41	9.795891	9.894435	9.903455	10.096544	10.107565	10.204109	19
42	9.796049	9.894534	9.903714	10.096286	10.107666	10.203951	18
43	9.796206	9.894633	9.903973	10.096027	10.107767	10.203794	17
44	9.796364	9.894732	9.904232	10.095768	10.107868	10.203636	16
45	9.796521	9.894830	9.904491	10.095509	10.107970	10.203479	15
46	9.796679	9.894929	9.904750	10.095250	10.108071	10.203321	14
47	9.796836	9.895027	9.905008	10.094991	10.108173	10.203164	13
48	9.796993	9.895126	9.905267	10.094733	10.108274	10.203007	12
49	9.797150	9.895224	9.905526	10.094474	10.108376	10.202850	11
50	9.797307	9.895323	9.905784	10.094215	10.108477	10.202693	10
51	9.797464	9.895421	9.906043	10.093957	10.108579	10.202536	9
52	9.797621	9.895519	9.906302	10.093698	10.108681	10.202379	8
53	9.797777	9.895617	9.906560	10.093440	10.108781	10.202222	7
54	9.797934	9.895715	9.906819	10.093181	10.108885	10.202066	6
55	9.798091	9.895813	9.907077	10.092923	10.108987	10.201909	5
56	9.798247	9.895911	9.907336	10.092664	10.109089	10.201753	4
57	9.798403	9.896009	9.907594	10.092406	10.109191	10.201597	3
58	9.798560	9.896107	9.907852	10.092147	10.109293	10.201440	2
59	9.798716	9.896205	9.908111	10.091889	10.109395	10.201284	1
60	9.798872	9.896303	9.908369	10.091631	10.109497	10.201128	0
	Sine.		Tang.		Secant.		Min.

51 Degrees.

L 14

39 Degrees.

Min.	Sine.		Tang		Secant.	
0	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128
1	9.799028	9.890400	9.908627	10.091372	10.109600	10.200972
2	9.799184	9.890298	9.908886	10.091114	10.109702	10.200816
3	9.799339	9.890195	9.909144	10.090856	10.109805	10.200661
4	9.799495	9.890093	9.909402	10.090598	10.109907	10.200505
5	9.799651	9.889990	9.909660	10.090340	10.110010	10.200349
6	9.799806	9.889888	9.909918	10.090081	10.110112	10.200194
7	9.799962	9.889785	9.910177	10.089823	10.110215	10.200038
8	9.800117	9.889682	9.910435	10.089565	10.110318	10.199883
9	9.800272	9.889579	9.910693	10.089307	10.110421	10.199728
10	9.800427	9.889476	9.910951	10.089049	10.110523	10.199573
11	9.800582	9.889374	9.911209	10.088791	10.110626	10.199418
12	9.800737	9.889271	9.911467	10.088533	10.110729	10.199263
13	9.800892	9.889167	9.911724	10.088275	10.110832	10.199108
14	9.801047	9.889064	9.911982	10.088018	10.110936	10.198953
15	9.801201	9.888961	9.912240	10.087760	10.111039	10.198798
16	9.801356	9.888858	9.912498	10.087502	10.111142	10.198644
17	9.801511	9.888755	9.912756	10.087244	10.111245	10.198489
18	9.801665	9.888651	9.913014	10.086986	10.111349	10.198335
19	9.801819	9.888548	9.913271	10.086729	10.111452	10.198181
20	9.801973	9.888444	9.913529	10.086471	10.111556	10.198026
21	9.802128	9.888341	9.913787	10.086213	10.111659	10.197872
22	9.802282	9.888237	9.914044	10.085956	10.111763	10.197718
23	9.802435	9.888133	9.914302	10.085698	10.111866	10.197564
24	9.802589	9.888030	9.914560	10.085440	10.111970	10.197411
25	9.802743	9.887926	9.914817	10.085183	10.112074	10.197257
26	9.802897	9.887822	9.915075	10.084925	10.112178	10.197103
27	9.803050	9.887718	9.915332	10.084668	10.112282	10.196950
28	9.803204	9.887614	9.915590	10.084410	10.112386	10.196796
29	9.803357	9.887510	9.915847	10.084153	10.112490	10.196643
30	9.803510	9.887406	9.916104	10.083895	10.112594	10.196489
		Sine.		Tang.		Secant.

50 Degrees.

Tangents and Secants.

505

39 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.803510	9.887400	9.916104	10.083895	10.112594	10.195489	30
31	9.803664	9.887302	9.916362	10.083638	10.112698	10.196336	29
32	9.803817	9.887198	9.916619	10.083381	10.112802	10.196183	28
33	9.803970	9.887093	9.916876	10.083123	10.112907	10.196030	27
34	9.804122	9.886989	9.917134	10.082866	10.113011	10.195877	26
35	9.804276	9.886885	9.917391	10.082609	10.113115	10.195724	25
36	9.804428	9.886780	9.917648	10.082352	10.113220	10.195572	24
37	9.804581	9.886676	9.917905	10.082094	10.113324	10.195419	23
38	9.804734	9.886571	9.918163	10.081837	10.113429	10.195266	22
39	9.804886	9.886466	9.918420	10.081580	10.113534	10.195114	21
40	9.805038	9.886362	9.918677	10.081323	10.113638	10.194961	20
41	9.805191	9.886257	9.918934	10.081066	10.113743	10.194809	19
42	9.805343	9.886152	9.919191	10.080809	10.113848	10.194657	18
43	9.805495	9.886047	9.919448	10.080552	10.113953	10.194505	17
44	9.805647	9.885942	9.919705	10.080295	10.114058	10.194352	16
45	9.805799	9.885837	9.919962	10.080038	10.114163	10.194201	15
46	9.805951	9.885732	9.920219	10.079781	10.114268	10.194049	14
47	9.806103	9.885627	9.920476	10.079524	10.114373	10.193897	13
48	9.806254	9.885521	9.920733	10.079267	10.114478	10.193746	12
49	9.806406	9.885416	9.920990	10.079010	10.114584	10.193594	11
50	9.806557	9.885311	9.921247	10.078753	10.114689	10.193442	10
51	9.806709	9.885205	9.921503	10.078497	10.114794	10.193291	9
52	9.806860	9.885100	9.921760	10.078240	10.114900	10.193140	8
53	9.807011	9.884994	9.922017	10.077983	10.115005	10.192989	7
54	9.807162	9.884889	9.922274	10.077726	10.115111	10.192837	6
55	9.807314	9.884783	9.922530	10.077470	10.115217	10.192686	5
56	9.807465	9.884677	9.922787	10.077213	10.115322	10.192535	4
57	9.807615	9.884572	9.923044	10.076956	10.115428	10.192385	3
58	9.807766	9.884466	9.923300	10.076700	10.115534	10.192234	2
59	9.807917	9.884360	9.923557	10.076443	10.115640	10.192083	1
60	9.808067	9.884254	9.923812	10.076186	10.115746	10.191932	0
	Sine.		Tang.		Secant.		Min.

50 Degrees.

40 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.808067	9.884254	9.923813	10.076186	10.115746	10.191912
1	9.808218	9.884148	9.924070	10.075930	10.115852	10.191782
2	9.808368	9.884042	9.924327	10.075673	10.115958	10.191632
3	9.808519	9.883936	9.924583	10.075417	10.116064	10.191481
4	9.808669	9.883829	9.924840	10.075160	10.116170	10.191331
5	9.808819	9.883723	9.925096	10.074904	10.116277	10.191180
6	9.808969	9.883617	9.925352	10.074648	10.116383	10.191030
7	9.809119	9.883510	9.925609	10.074391	10.116490	10.190881
8	9.809269	9.883404	9.925865	10.074135	10.116596	10.190731
9	9.809419	9.883297	9.926121	10.073878	10.116702	10.190581
10	9.809569	9.883191	9.926378	10.073622	10.116809	10.190431
11	9.809718	9.883084	9.926634	10.073366	10.116916	10.190282
12	9.809868	9.882977	9.926890	10.073110	10.117023	10.190132
13	9.810017	9.882871	9.927147	10.072853	10.117129	10.189983
14	9.810167	9.882764	9.927403	10.072597	10.117236	10.189833
15	9.810316	9.882657	9.927659	10.072341	10.117343	10.189684
16	9.810465	9.882550	9.927915	10.072085	10.117450	10.189535
17	9.810614	9.882443	9.928171	10.071829	10.117557	10.189386
18	9.810763	9.882336	9.928427	10.071573	10.117664	10.189237
19	9.810912	9.882228	9.928683	10.071316	10.117771	10.189088
20	9.811061	9.882121	9.928940	10.071060	10.117879	10.188939
21	9.811210	9.882014	9.929196	10.070804	10.117986	10.188790
22	9.811358	9.881907	9.929452	10.070548	10.118093	10.188642
23	9.811507	9.881799	9.929708	10.070292	10.118201	10.188493
24	9.811655	9.881692	9.929964	10.070036	10.118308	10.188345
25	9.811804	9.881584	9.930219	10.069780	10.118416	10.188196
26	9.811952	9.881477	9.930475	10.069524	10.118523	10.188048
27	9.812100	9.881369	9.930731	10.069269	10.118631	10.187900
28	9.812248	9.881261	9.930987	10.069013	10.118739	10.187752
29	9.812396	9.881153	9.931243	10.068757	10.118847	10.187603
30	9.812544	9.881045	9.931499	10.068501	10.118954	10.187456
	Sine.		Tang.		Secant.	Min.

49 Degrees.

Tangents and Secants.

507

40 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.812344	9.881045	9.931499	10.068501
31	9.812692	9.880938	9.931755	10.068245
32	9.812840	9.880830	9.932010	10.067989
33	9.812988	9.880721	9.932266	10.067734
34	9.813135	9.880613	9.932522	10.067478
35	9.813283	9.880505	9.932778	10.067222
36	9.813430	9.880397	9.933033	10.066967
37	9.813578	9.880289	9.933289	10.066711
38	9.813725	9.880180	9.933545	10.066455
39	9.813872	9.880072	9.933800	10.066200
40	9.814019	9.879963	9.934056	10.065944
41	9.814166	9.879855	9.934311	10.065689
42	9.814313	9.879746	9.934567	10.065433
43	9.814460	9.879637	9.934822	10.065177
44	9.814607	9.879529	9.935078	10.064922
45	9.814755	9.879420	9.935333	10.064666
46	9.814900	9.879311	9.935589	10.064411
47	9.815046	9.879202	9.935844	10.064156
48	9.815193	9.879093	9.936100	10.063900
49	9.815339	9.878984	9.936355	10.063645
50	9.815485	9.878875	9.936610	10.063386
51	9.815531	9.878766	9.936866	10.063134
52	9.815778	9.878656	9.937121	10.062879
53	9.815923	9.878547	9.937376	10.062622
54	9.816069	9.878438	9.937632	10.062368
55	9.816215	9.878328	9.937887	10.062113
56	9.816361	9.878219	9.938142	10.061858
57	9.816507	9.878109	9.938397	10.061602
58	9.816652	9.877999	9.938653	10.061347
59	9.816797	9.877890	9.938908	10.061092
60	9.816943	9.877780	9.939163	10.060837
	Sine.	Tang.	Secant.	Min.

49 Degrees.

41 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057
1	9.817088	9.877670	9.939418	10.060582	10.122330	10.182912
2	9.817233	9.877560	9.939673	10.060327	10.122440	10.182767
3	9.817378	9.877450	9.939928	10.060072	10.122550	10.182621
4	9.817523	9.877340	9.940183	10.059816	10.122660	10.182476
5	9.817668	9.877230	9.940438	10.059561	10.122770	10.182331
6	9.817813	9.877120	9.940694	10.059306	10.122880	10.182187
7	9.817958	9.877010	9.940949	10.059051	10.122990	10.182042
8	9.818103	9.876899	9.941204	10.058796	10.123101	10.181897
9	9.818247	9.876789	9.941458	10.058541	10.123211	10.181753
10	9.818392	9.876678	9.941713	10.058286	10.123321	10.181608
11	9.818536	9.876568	9.941958	10.058032	10.123432	10.181464
12	9.818681	9.876457	9.942223	10.057777	10.123543	10.181319
13	9.818825	9.876347	9.942478	10.057522	10.123653	10.181175
14	9.818969	9.876236	9.942733	10.057267	10.123764	10.181031
15	9.819113	9.876125	9.942988	10.057012	10.123875	10.180887
16	9.819258	9.876014	9.943243	10.056757	10.123985	10.180742
17	9.819401	9.875904	9.943498	10.056502	10.124096	10.180598
18	9.819545	9.875793	9.943752	10.056248	10.124207	10.180453
19	9.819689	9.875682	9.944007	10.055993	10.124318	10.180311
20	9.819832	9.875571	9.944262	10.055738	10.124429	10.180167
21	9.819976	9.875459	9.944517	10.055483	10.124541	10.180024
22	9.820120	9.875348	9.944771	10.055229	10.124652	10.179880
23	9.820263	9.875237	9.945026	10.054974	10.124763	10.179737
24	9.820406	9.875126	9.945281	10.054719	10.124874	10.179594
25	9.820550	9.875014	9.945535	10.054465	10.124986	10.179450
26	9.820693	9.874903	9.945790	10.054210	10.125097	10.179307
27	9.820836	9.874791	9.946045	10.053955	10.125209	10.179164
28	9.820979	9.874679	9.946299	10.053701	10.125320	10.179021
29	9.821122	9.874568	9.946554	10.053446	10.125432	10.178878
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735
	Sine.		Tang.		Secant.	Min.

48 Degrees.

Tangents and Secants.

509

41 Degrees.

Min.	Sine.		Tang.		Secant.		
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
31	9.821470	9.874344	9.947063	10.052937	10.125656	10.178593	29
32	9.821550	9.874232	9.947317	10.052682	10.125767	10.178450	28
33	9.821693	9.874120	9.947572	10.052428	10.125879	10.178307	27
34	9.821835	9.874008	9.947826	10.052173	10.125991	10.178165	26
35	9.821977	9.873896	9.948081	10.051919	10.126103	10.178022	25
36	9.822120	9.873784	9.948335	10.051664	10.126216	10.177880	24
37	9.822262	9.873672	9.948590	10.051410	10.126328	10.177738	23
38	9.822404	9.873560	9.948844	10.051156	10.126440	10.177596	22
39	9.822546	9.873448	9.949099	10.050901	10.126552	10.177454	21
40	9.822688	9.873335	9.949353	10.050647	10.126665	10.177312	20
41	9.822830	9.873223	9.949607	10.050392	10.126777	10.177170	19
42	9.822972	9.873110	9.949862	10.050138	10.126890	10.177028	18
43	9.823114	9.872998	9.950116	10.049884	10.127002	10.176886	17
44	9.823255	9.872885	9.950370	10.049629	10.127115	10.176744	16
45	9.823397	9.872772	9.950625	10.049375	10.127228	10.176603	15
46	9.823539	9.872659	9.950879	10.049121	10.127341	10.176461	14
47	9.823680	9.872547	9.951133	10.048867	10.127453	10.176320	13
48	9.823821	9.872434	9.951388	10.048612	10.127566	10.176179	12
49	9.823963	9.872321	9.951642	10.048358	10.127679	10.176037	11
50	9.824104	9.872208	9.951896	10.048104	10.127792	10.175896	10
51	9.824245	9.872094	9.952150	10.047850	10.127905	10.175755	9
52	9.824386	9.871981	9.952404	10.047595	10.128019	10.175614	8
53	9.824527	9.871868	9.952659	10.047341	10.128132	10.175473	7
54	9.824668	9.871755	9.952913	10.047087	10.128245	10.175332	6
55	9.824808	9.871641	9.953167	10.046833	10.128359	10.175192	5
56	9.824949	9.871528	9.953421	10.046579	10.128472	10.175051	4
57	9.825090	9.871414	9.953675	10.046325	10.128586	10.174910	3
58	9.825230	9.871301	9.953929	10.046071	10.128699	10.174770	2
59	9.825370	9.871187	9.954183	10.045817	10.128813	10.174629	1
60	9.825511	9.871073	9.954437	10.045563	10.128926	10.174489	0
		Sine.		Tang.		Secant.	Min.

48 Degrees.

42 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.825511	9.871073	9.954437	10.045563	10.128926	10.174489
1	9.825651	9.870960	9.954691	10.045308	10.129040	10.174349
2	9.825791	9.870846	9.954945	10.045054	10.129154	10.174209
3	9.825931	9.870732	9.955199	10.044800	10.129268	10.174069
4	9.826071	9.870618	9.955453	10.044546	10.129382	10.173928
5	9.826211	9.870504	9.955707	10.044292	10.129496	10.173789
6	9.826351	9.870390	9.955961	10.044038	10.129610	10.173649
7	9.826491	9.870276	9.956215	10.043785	10.129724	10.173509
8	9.826631	9.870161	9.956469	10.043531	10.129839	10.173369
9	9.826770	9.870047	9.956723	10.043277	10.129953	10.173229
10	9.826910	9.869933	9.956977	10.043023	10.130067	10.173090
11	9.827049	9.869818	9.957231	10.042769	10.130182	10.172951
12	9.827189	9.869704	9.957485	10.042515	10.130296	10.172811
13	9.827328	9.869589	9.957739	10.042261	10.130411	10.172672
14	9.827467	9.869474	9.957993	10.042007	10.130526	10.172533
15	9.827606	9.869360	9.958246	10.041753	10.130640	10.172394
16	9.827745	9.869245	9.958500	10.041500	10.130755	10.172255
17	9.827884	9.869130	9.958754	10.041246	10.130870	10.172116
18	9.828023	9.869015	9.959008	10.040992	10.130985	10.171977
19	9.828162	9.868900	9.959262	10.040738	10.131100	10.171838
20	9.828301	9.868785	9.959515	10.040484	10.131215	10.171699
21	9.828439	9.868670	9.959770	10.040231	10.131330	10.171561
22	9.828578	9.868555	9.960023	10.039977	10.131445	10.171422
23	9.828716	9.868440	9.960277	10.039723	10.131560	10.171284
24	9.828855	9.868324	9.960530	10.039470	10.131676	10.171145
25	9.828993	9.868209	9.960784	10.039216	10.131791	10.171007
26	9.829131	9.868093	9.961038	10.038962	10.131907	10.170869
27	9.829269	9.867978	9.961291	10.038708	10.132022	10.170731
28	9.829407	9.867862	9.961545	10.038455	10.132138	10.170592
29	9.829545	9.867747	9.961799	10.038201	10.132253	10.170455
30	9.829683	9.867631	9.962052	10.037947	10.132369	10.170317
	Sine.		Tang.		Secant.	Min.

47 Degrees.

Tangents and Secants.

511

42 Degrees.

Min.	Sine.	Tang.	Secant.	
30	9.829683	9.867631	9.962053	10.037947
31	9.829821	9.867515	9.962306	10.037694
32	9.829959	9.867399	9.962560	10.037440
33	9.830097	9.867283	9.962813	10.037187
34	9.830234	9.867167	9.963067	10.036933
35	9.830372	9.867051	9.963320	10.036680
36	9.830509	9.866935	9.963574	10.036426
37	9.830646	9.866819	9.963827	10.036172
38	9.830784	9.866703	9.964081	10.035919
39	9.830921	9.866586	9.964335	10.035665
40	9.831058	9.866470	9.964588	10.035412
41	9.831195	9.866353	9.964842	10.035158
42	9.831332	9.866237	9.965095	10.034905
43	9.831469	9.866120	9.965349	10.034651
44	9.831606	9.866004	9.965602	10.034399
45	9.831742	9.865887	9.965855	10.034144
46	9.831879	9.865770	9.966109	10.033891
47	9.832015	9.865653	9.966362	10.033638
48	9.832152	9.865536	9.966616	10.033384
49	9.832288	9.865419	9.966869	10.033131
50	9.832425	9.865302	9.967122	10.032877
51	9.832561	9.865185	9.967376	10.032624
52	9.832697	9.865068	9.967630	10.032371
53	9.832833	9.864950	9.967883	10.032117
54	9.832970	9.864833	9.968136	10.031864
55	9.833105	9.864716	9.968389	10.031611
56	9.833241	9.864598	9.968643	10.031357
57	9.833377	9.864481	9.968897	10.031104
58	9.833512	9.864363	9.969150	10.030851
59	9.833648	9.864245	9.969403	10.030597
60	9.833783	9.864127	9.969656	10.030344
	Sine.	Tang.	Secant.	Min.

47 Degrees.

43 Degrees.

Min.	Sine.		Tang.		Secant.	
0	9.833783	9.864127	9.969656	10.030344	10.135872	10.166217
1	9.833919	9.864010	9.969909	10.030091	10.135990	10.166081
2	9.834054	9.863892	9.970162	10.029838	10.136108	10.165946
3	9.834189	9.863774	9.970416	10.029584	10.136226	10.165811
4	9.834325	9.863656	9.970669	10.029331	10.136344	10.165675
5	9.834460	9.863537	9.970922	10.029078	10.136462	10.165540
6	9.834595	9.863419	9.971175	10.028825	10.136581	10.165405
7	9.834730	9.863301	9.971429	10.028571	10.136699	10.165270
8	9.834865	9.863183	9.971682	10.028318	10.136816	10.165135
9	9.834999	9.863064	9.971935	10.028065	10.136936	10.165001
10	9.835134	9.862946	9.972188	10.027812	10.137054	10.164866
11	9.835269	9.862827	9.972441	10.027559	10.137173	10.164731
12	9.835403	9.862709	9.972695	10.027305	10.137291	10.164597
13	9.835538	9.862590	9.972948	10.027052	10.137410	10.164462
14	9.835672	9.862471	9.973201	10.026799	10.137529	10.164328
15	9.835807	9.862353	9.973454	10.026546	10.137647	10.164193
16	9.835941	9.862234	9.973707	10.026293	10.137766	10.164059
17	9.836075	9.862115	9.973960	10.026040	10.137885	10.163925
18	9.836209	9.861996	9.974213	10.025787	10.138004	10.163791
19	9.836343	9.861877	9.974466	10.025534	10.138123	10.163657
20	9.836477	9.861758	9.974719	10.025280	10.138242	10.163523
21	9.836611	9.861638	9.974973	10.025027	10.138362	10.163389
22	9.836745	9.861519	9.975226	10.024774	10.138481	10.163255
23	9.836878	9.861400	9.975479	10.024521	10.138600	10.163122
24	9.837012	9.861280	9.975732	10.024268	10.138720	10.162988
25	9.837146	9.861161	9.975985	10.024015	10.138839	10.162854
26	9.837279	9.861041	9.976238	10.023762	10.138959	10.162721
27	9.837411	9.860921	9.976491	10.023509	10.139078	10.162587
28	9.837546	9.860802	9.976744	10.023256	10.139198	10.162454
29	9.837679	9.860682	9.976997	10.023003	10.139318	10.162321
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162189
	Sine.		Tang.		Secant.	Min.

46 Degrees.

Tangents and Secants.

513

43 Degrees.

Min.	Sine.		Tang.		Secant.		Min.
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
31	9.837945	9.860442	9.977503	10.022497	10.139558	10.162055	29
32	9.838078	9.860322	9.977756	10.022244	10.139678	10.161922	28
33	9.838211	9.860202	9.978009	10.021991	10.139798	10.161789	27
34	9.838344	9.860082	9.978262	10.021738	10.139918	10.161656	26
35	9.838477	9.859962	9.978515	10.021485	10.140038	10.161523	25
36	9.838610	9.859842	9.978768	10.021232	10.140158	10.161390	24
37	9.838742	9.859721	9.979021	10.020979	10.140279	10.161258	23
38	9.838875	9.859601	9.979274	10.020726	10.140399	10.161125	22
39	9.839007	9.859480	9.979527	10.020473	10.140520	10.160993	21
40	9.839140	9.859360	9.979780	10.020220	10.140640	10.160860	20
41	9.839272	9.859239	9.980033	10.019967	10.140761	10.160728	19
42	9.839404	9.859119	9.980286	10.019714	10.140881	10.160596	18
43	9.839536	9.858998	9.980538	10.019461	10.141002	10.160464	17
44	9.839668	9.858877	9.980791	10.019209	10.141123	10.160332	16
45	9.839800	9.858756	9.981044	10.018956	10.141244	10.160200	15
46	9.839932	9.858635	9.981297	10.018703	10.141365	10.160068	14
47	9.840064	9.858514	9.981550	10.018450	10.141486	10.159936	13
48	9.840196	9.858393	9.981803	10.018197	10.141607	10.159804	12
49	9.840328	9.858272	9.982056	10.017944	10.141728	10.159672	11
50	9.840460	9.858150	9.982309	10.017691	10.141849	10.159541	10
51	9.840591	9.858029	9.982562	10.017438	10.141971	10.159409	9
52	9.840722	9.857908	9.982814	10.017185	10.142092	10.159278	8
53	9.840854	9.857786	9.983067	10.016933	10.142214	10.159146	7
54	9.840985	9.857666	9.983320	10.016680	10.142335	10.159015	6
55	9.841116	9.857543	9.983573	10.016427	10.142457	10.158884	5
56	9.841247	9.857421	9.983826	10.016174	10.142578	10.158753	4
57	9.841378	9.857300	9.984079	10.015921	10.142700	10.158621	3
58	9.841509	9.857178	9.984331	10.015668	10.142822	10.158490	2
59	9.841640	9.857056	9.984584	10.015416	10.142944	10.158360	1
60	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	0
	Sine.		Tang.		Secant.		Min.

46 Degrees.

M m

44 Degrees.

Min.	Sine.	Tang.	Secant.	Min.			
0	9.841771	9.856934	9.984837	10.015163	10.141066	10.158229	60
1	9.841902	9.856812	9.985090	10.014910	10.143188	10.158098	59
2	9.842033	9.856690	9.985343	10.014657	10.143310	10.157967	58
3	9.842163	9.856568	9.985596	10.014404	10.143432	10.157837	57
4	9.842294	9.856445	9.985848	10.014152	10.143554	10.157706	56
5	9.842424	9.856323	9.986101	10.013899	10.143677	10.157576	55
6	9.842555	9.856201	9.986354	10.013646	10.143799	10.157445	54
7	9.842685	9.856078	9.986607	10.013393	10.143922	10.157315	53
8	9.842815	9.855956	9.986860	10.013140	10.144044	10.157185	52
9	9.842946	9.855833	9.987112	10.012888	10.144167	10.157054	51
10	9.843076	9.855711	9.987365	10.012635	10.144289	10.156924	50
11	9.843207	9.855588	9.987618	10.012382	10.144412	10.156794	49
12	9.843336	9.855465	9.987871	10.012129	10.144535	10.156664	48
13	9.843465	9.855343	9.988123	10.011877	10.144658	10.156534	47
14	9.843595	9.855219	9.988376	10.011624	10.144781	10.156405	46
15	9.843725	9.855096	9.988629	10.011371	10.144904	10.156275	45
16	9.843855	9.854973	9.988882	10.011118	10.145027	10.156145	44
17	9.843984	9.854850	9.989134	10.010866	10.145150	10.156016	43
18	9.844114	9.854727	9.989387	10.010613	10.145273	10.155886	42
19	9.844243	9.854603	9.989640	10.010360	10.145397	10.155757	41
20	9.844373	9.854480	9.989893	10.010107	10.145520	10.155627	40
21	9.844502	9.854356	9.990145	10.009855	10.145644	10.155498	39
22	9.844631	9.854233	9.990398	10.009602	10.145767	10.155369	38
23	9.844760	9.854109	9.990651	10.009349	10.145891	10.155240	37
24	9.844889	9.853986	9.990903	10.009096	10.146014	10.155111	36
25	9.845018	9.853862	9.991156	10.008844	10.146138	10.154982	35
26	9.845147	9.853738	9.991409	10.008591	10.146262	10.154853	34
27	9.845276	9.853614	9.991662	10.008338	10.146386	10.154724	33
28	9.845404	9.853490	9.991914	10.008086	10.146510	10.154595	32
29	9.845533	9.853366	9.992167	10.007833	10.146634	10.154467	31
30	9.845662	9.853242	9.992420	10.007580	10.146758	10.154338	30
	Sine.		Tang.			Secant.	Min.

45 Degrees.

Tangents and Secants.

515

44 Degrees.

Min.	Sine.		Tang.		Secant.	
30	9.845602	9.853242	9.992420	10.007580	10.146758	10.154338
31	9.845790	9.853118	9.992672	10.007328	10.146882	10.154210
32	9.845919	9.852994	9.992925	10.007075	10.147006	10.154081
33	9.846047	9.852869	9.993178	10.006822	10.147131	10.153952
34	9.846175	9.852745	9.993430	10.006569	10.147255	10.153825
35	9.846304	9.852620	9.993683	10.006317	10.147380	10.153696
36	9.846432	9.852496	9.993936	10.006064	10.147504	10.153568
37	9.846560	9.852371	9.994189	10.005811	10.147629	10.153440
38	9.846688	9.852247	9.994441	10.005559	10.147753	10.153312
39	9.846816	9.852122	9.994694	10.005306	10.147878	10.153184
40	9.846944	9.851997	9.994947	10.005053	10.148003	10.153056
41	9.847071	9.851872	9.995199	10.004801	10.148128	10.152929
42	9.847199	9.851747	9.995452	10.004548	10.148253	10.152801
43	9.847327	9.851621	9.995705	10.004295	10.148378	10.152673
44	9.847454	9.851497	9.995957	10.004043	10.148503	10.152546
45	9.847582	9.851372	9.996210	10.003790	10.148628	10.152418
46	9.847709	9.851246	9.996462	10.003537	10.148753	10.152291
47	9.847836	9.851121	9.996715	10.003285	10.148879	10.152163
48	9.847964	9.850996	9.996968	10.003032	10.149004	10.152036
49	9.848091	9.850870	9.997221	10.002779	10.149130	10.151909
50	9.848218	9.850745	9.997473	10.002527	10.149255	10.151782
51	9.848345	9.850619	9.997726	10.002274	10.149381	10.151655
52	9.848472	9.850493	9.997979	10.002021	10.149507	10.151528
53	9.848599	9.850367	9.998231	10.001769	10.149632	10.151401
54	9.848726	9.850242	9.998484	10.001516	10.149758	10.151274
55	9.848852	9.850116	9.998737	10.001263	10.149884	10.151148
56	9.848979	9.849990	9.998989	10.001011	10.150010	10.151021
57	9.849106	9.849864	9.999242	10.000758	10.150136	10.150894
58	9.849232	9.849737	9.999495	10.000505	10.150262	10.150768
59	9.849359	9.849611	9.999747	10.000253	10.150389	10.150641
60	9.849485	9.849485	10.000000	10.000000	10.150515	10.150515
	Sine.		Tang.		Secant.	Min.

45 Degrees.

F I N I S.

ERRATA.

In the Figure, Page 5, place the Letter S at the Left Hand Corner.

Page 114, Line the last, for $\frac{7}{10}$ read $\frac{9}{10}$.

Page 216, line 1, for *St. George's Channel*, read *the British Channel*.

Page 234, line 33, for *Left Hand*, read *Right Hand*.

Page 265, line 5, for *Ecliptick*, read *Equator*.

Page 265, line 31, for 6, read b.

Page 290 to 298, is a Table of *Meridional Parts*, tho' by Mistake the Title is omitted.

If any other material Mistakes have escaped either the Author or Printer, the Reader is desired to observe and correct them, the Author being Remote from the Press while most of the Copy was Printing.



